克里斯托夫·罗伊特

ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

bmwfw Bundesministerium für Wissenschaft, Forschung und Wirtschaft

pro Bell

BOSCH

TESLA

universität wien

声学、心理学与表演艺术等：维也纳大学的体系音乐学
上海音乐学院, 上海, 27.10.-4.11.2023

Research Talk

Timbre Measurement and more
Sounds you've never heard before
Living in a Box
Chilling on the Rocks
Scripts and Software to explore

研究报告

音色测量及其他
你从未听过的声音
生活在盒子里
岩石上的寒意
探索脚本和软件

Systematic Musicology

1 Timbre Measurement and more
The Wonderful World of Signal Analysis

2 Sounds you've never heard before
Perception with Exchangeable Ear Lobes in VR

3 Living in a Box
Noise Exposure in a Neonatal Intensive Care Unit (NICU)

4 Chilling on the Rocks
Music-induced Goosebumps (Chill Effect) while being drunk

5 Scripts and Software to explore
Further Applications and Developments

体系音乐学

1 音色测量及其他
奇妙的信号分析世界

2 你从未听过的声音
利用可交换耳叶在 VR 中感知声音

3 生活在盒子里
新生儿重症监护室 (NICU) 中的噪音暴露

4 岩石上的寒意
醉酒时音乐引起的鸡皮疙瘩（寒冷效应）

5 探索脚本和软件
进一步的应用和发展

Systematic Musicology 体系音乐学

1 音色测量及其他

奇妙的信号分析世界

1 Timbre Measurement and more

The Wonderful World of Signal Analysis

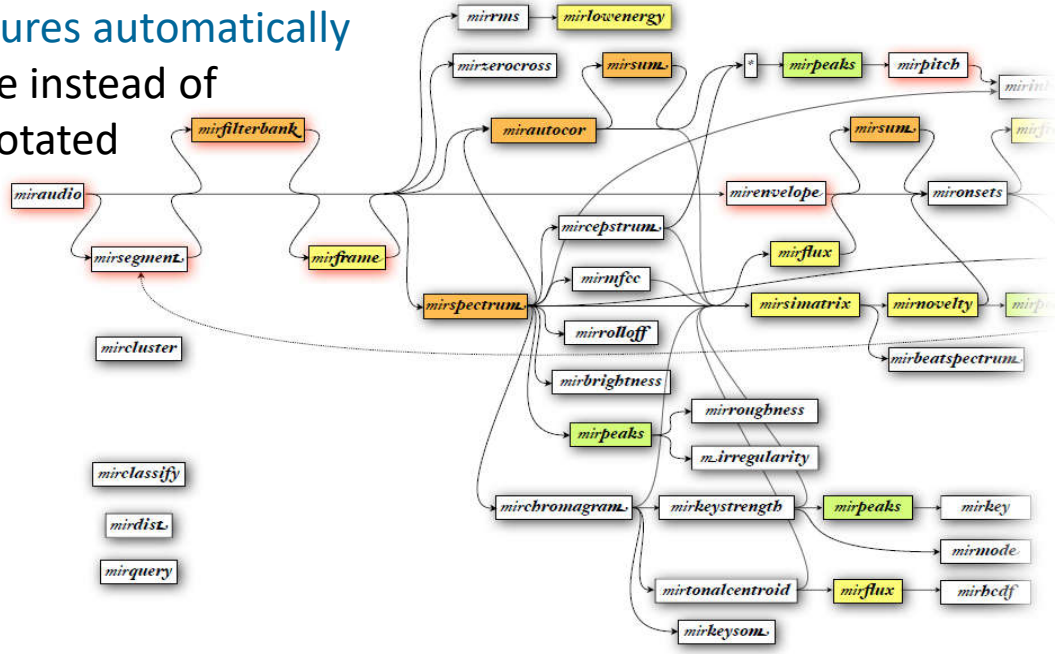
Systematic Musicology 体系音乐学

1 Timbre measurement

1 音色测量

1.1 Audio Signal Analysis

Since about 2000, it is possible to extract audio features automatically from the audio file instead of working with annotated metadata.



The manifold possibilities of the Matlab-MIRToolbox
Matlab-MIRToolbox 的多种可能性
(Lartillot, Toiviainen, Eerola 2007)

1.1 音频信号分析

大约从 2000 年开始, 人们可以从音频文件中自动提取音频特征, 而不是使用带注释的元数据.

Systematic Musicology 体系音乐学

1 Timbre measurement

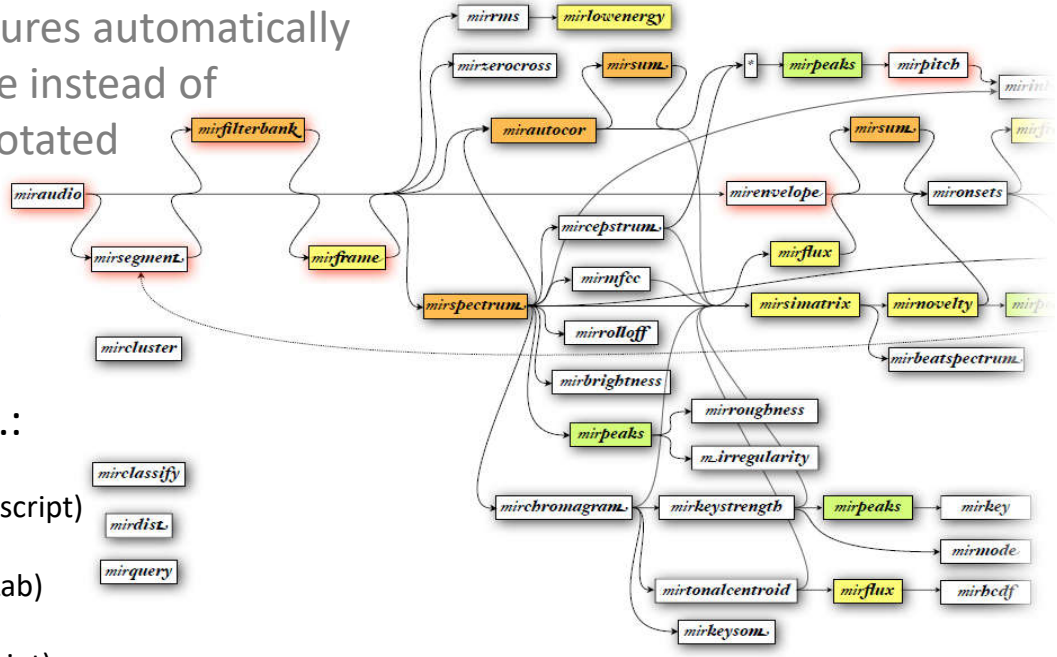
1 音色测量

1.1 Audio Signal Analysis

Since about 2000, it is possible to extract audio features automatically from the audio file instead of working with annotated metadata.

Common libraries for audio feature extraction are e.g.:

Essentia (for Python/Javascript)
LibROSA (for Python)
Timbre Toolbox (for MatLab)
MIRToolbox (for MatLab)
Aubio (for Python/Javascript)
Praat/Parselmouth (for Python)
etc.



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常见的音频特征提取库有:

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等等.

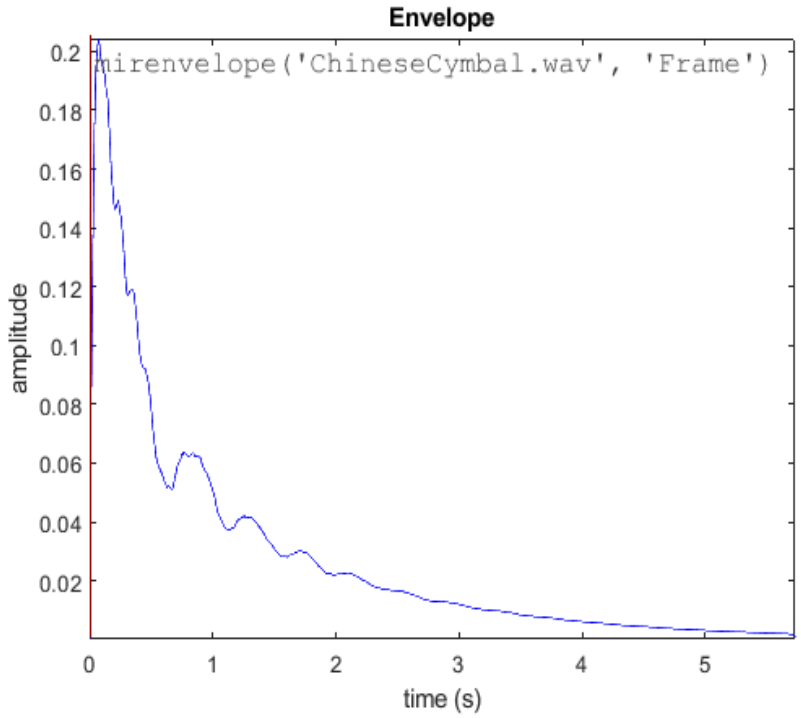
Systematic Musicology 体系音乐学

1 Timbre measurement

1 音色测量

1.1 Audio Signal Analysis

With the help of these libraries, timbre features like brightness, roughness, attack time can easily be extracted.



Extracting the Envelope and other features of a Chinese Cymbal simply with the line

提取中国钹的包络线和其他特征的曲线：

`mirenvelope('ChineseCymbal.wav','Frame')`

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在这些库的帮助下，可以轻松提取亮度、粗糙度、起音时间等音色特征.

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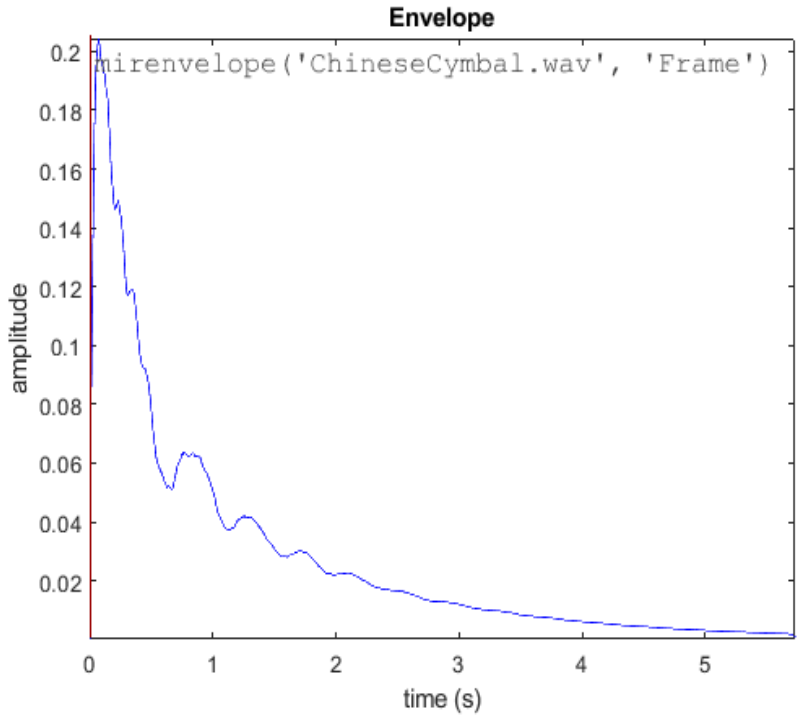
They are useful for similarity searches in music or voices, for genre classification, and for many other music-related tasks.



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它们对于音乐或声音的相似性搜索、流派分类以及许多其他与音乐相关的任务都很有用.

Systematic Musicology 体系音乐学

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1.1 Audio Signal Analysis

With the help of these libraries, timbre features like brightness, roughness, attack time can easily be extracted.

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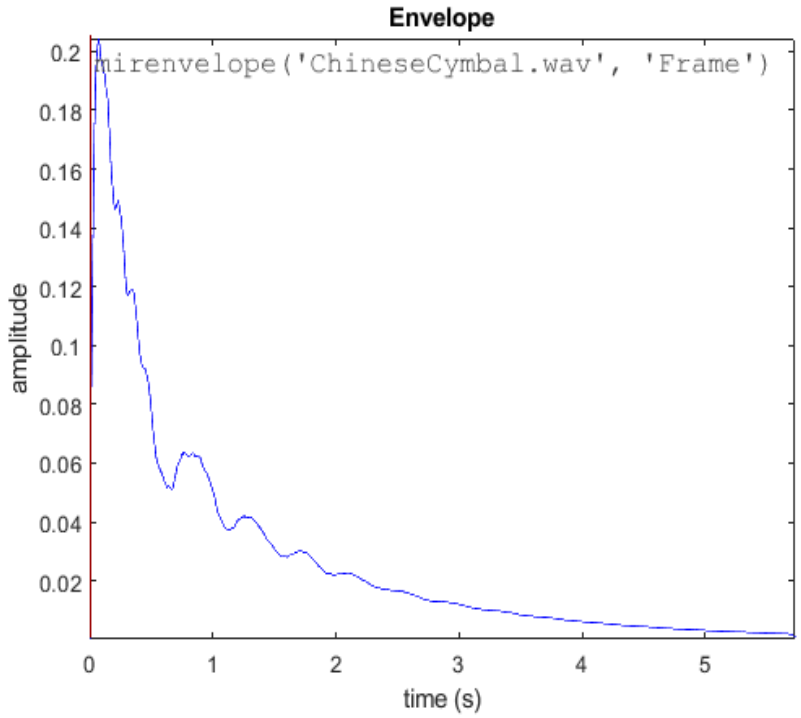
We often use audio feature extraction to determine human-like high-level descriptors for noises, sounds and music.



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我们经常使用音频特征提取来为噪音、声音和音乐确定类似人类的高级描述器.

Systematic Musicology 体系音乐学

奇泽迪克-艾森伯格, 维佐雷克, 路透社 2015-2023

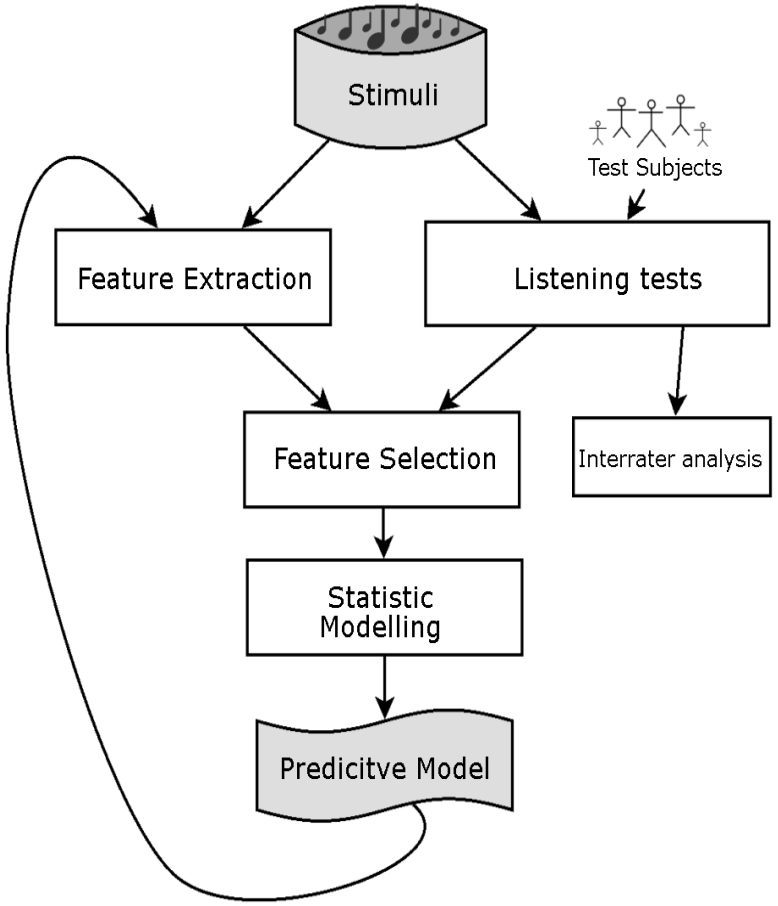
1 Timbre measurement

1 音色测量

1.2 PADMEA

Perceptual **A**udio **D**imension **M**odelling and **E**xtraction **A**pplication

1. Listening tests: Test Subjects evaluate a certain property of audio stimuli (e.g.: hardness. darkness etc.)



PADMEA flow diagram / PADMEA 流程图
(Czedik-Eysenberg 2022, p. 28)

1.2 PADMEA

感知音频维度建模和提取应用

1. 听力测试: 测试对象对音频刺激**的某种特性** 进行评估 (如: 硬度, 暗度等)

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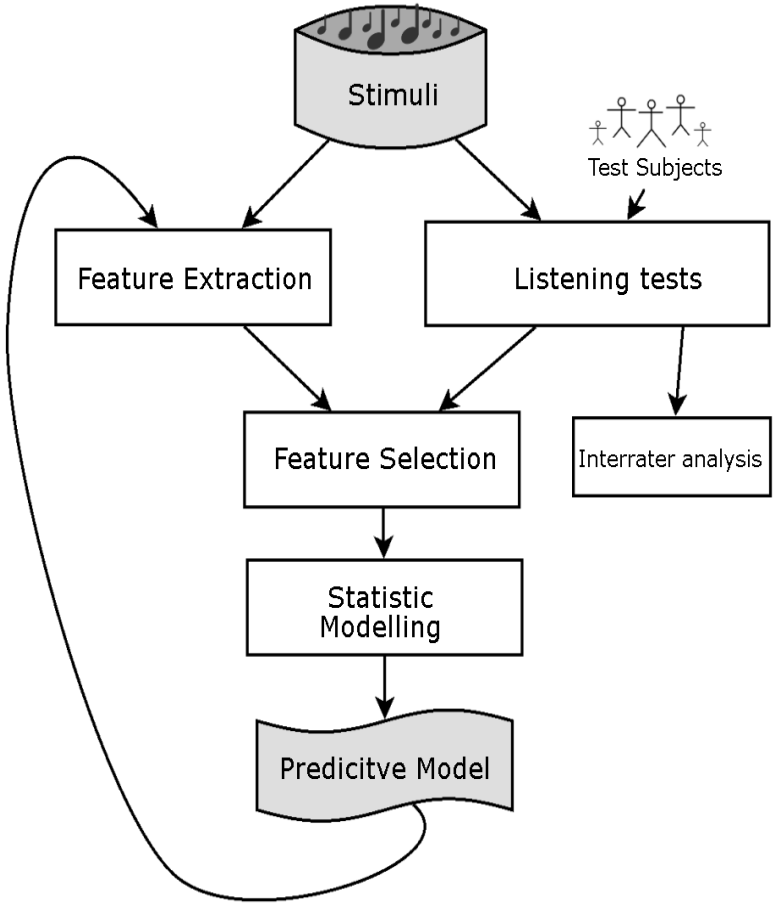

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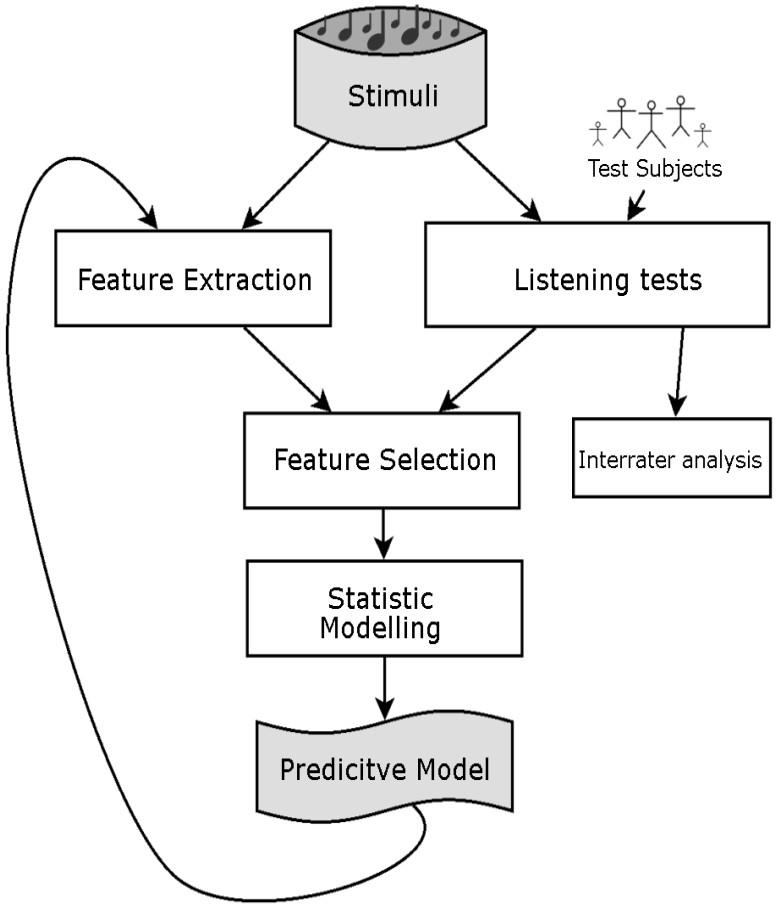

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Systematic Musicology 体系音乐学

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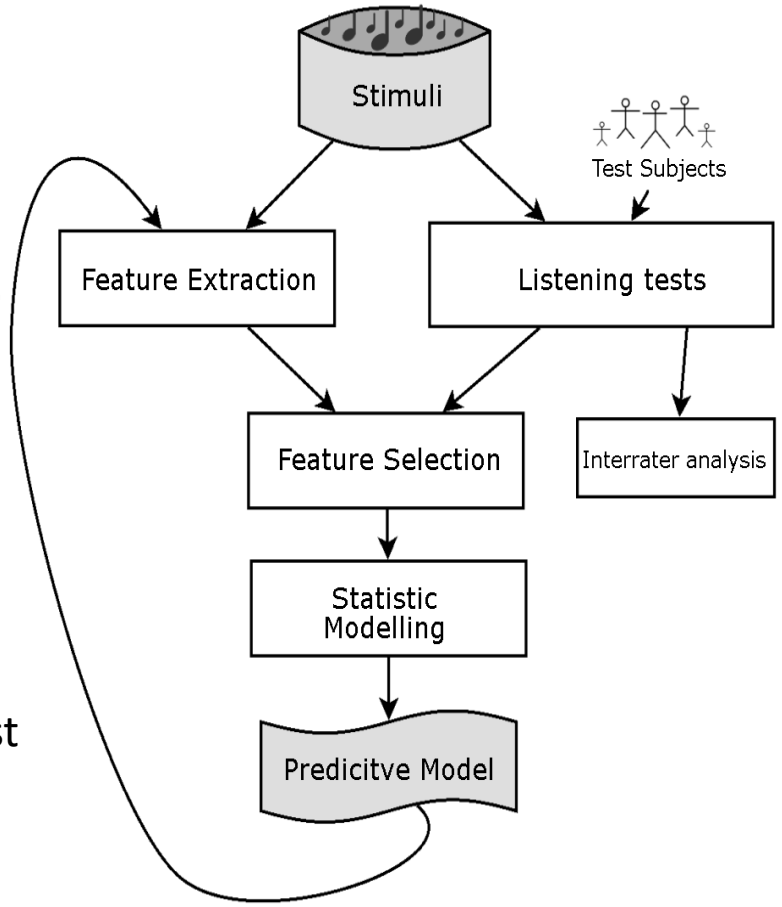

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4. **建立**统计模型, **找到最佳**预测模型 (k-NN, SFS, LASSO, **偏最小二乘回**归等)

Systematic Musicology 体系音乐学

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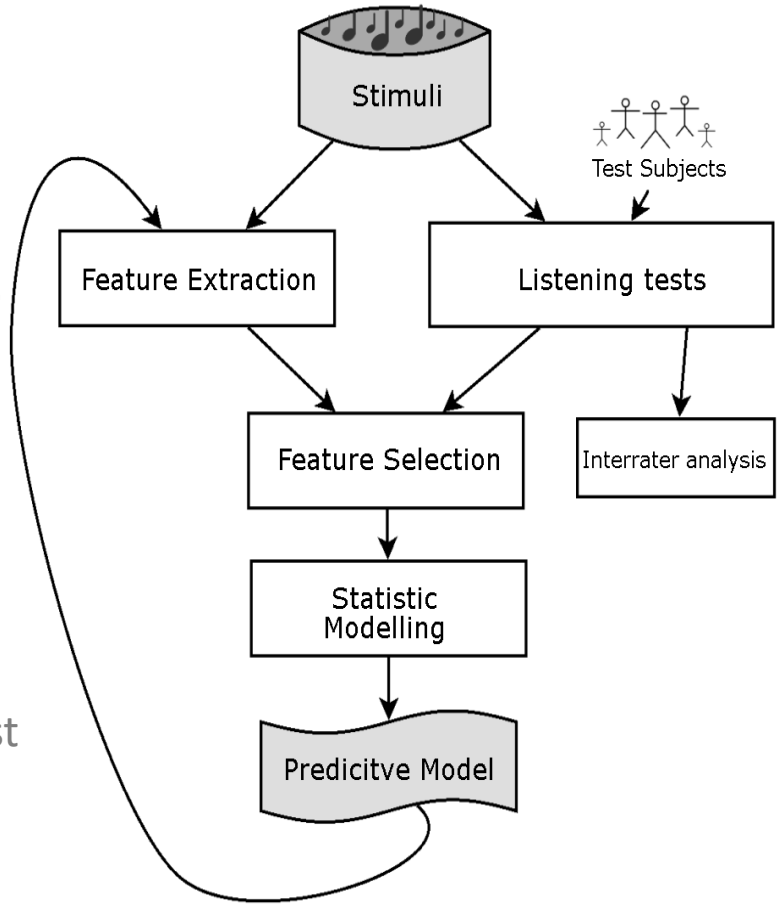
5. Adding the best predicitve model to the signal analysis algorithms



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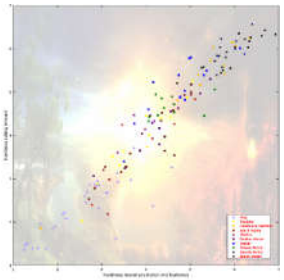
5. **将最佳**预测模型**添加到信号分析算法中**

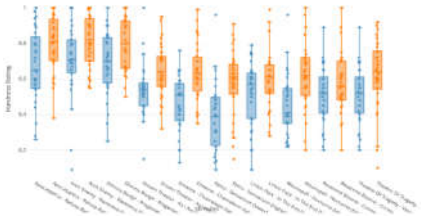
Systematic Musicology 体系音乐学

1 Timbre measurement and more

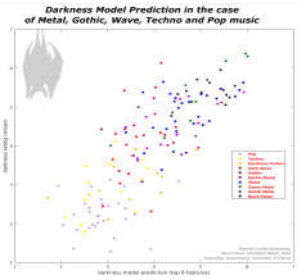
1 音色测量等



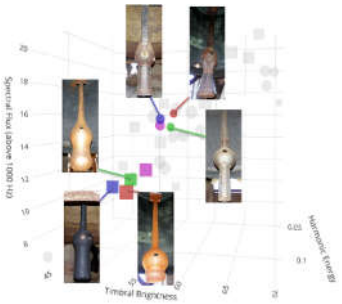
Hardness Map / 硬度图 (Czedik-Eysenberg, Knauf, Reuter 2017)



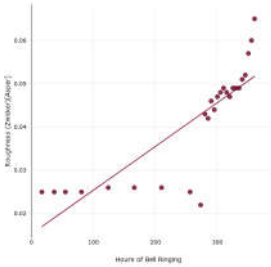
Hardinator / 硬度提取器 (Czedik-Eysenberg, Wiczorek, Reuter 2021)



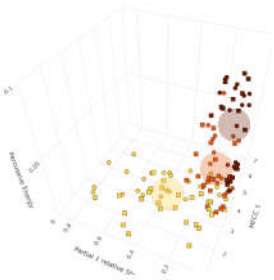
Darkness Map / 暗度映射 (Czedik-Eysenberg, Knauf, Reuter 2018)



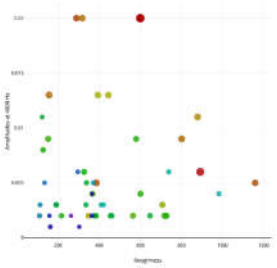
Bells Clapper / 钟声触发器 (Reuter, Plitzner, Czedik-Eysenberg, Roos, Siddiq etc. 2022)



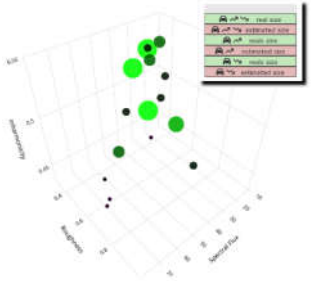
Bells Breaking Point / 铃声断点 (Reuter, Plitzner, Czedik-Eysenberg, Roos etc. 2023)



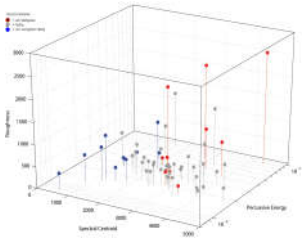
Bassoon Register Boundaries / 巴松管音域边界 (Reuter 2021)



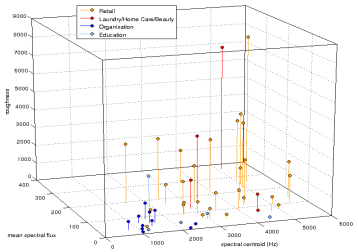
Rooster Annoyance / 公鸡的烦恼 (Reuter, Czedik-Eysenberg, Cui, et al. 2023)



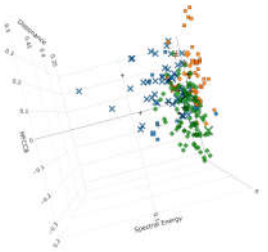
Electric Car Noises / 电动汽车噪音 (Ambros, Kuka, von Georgi, Reuter 2023)



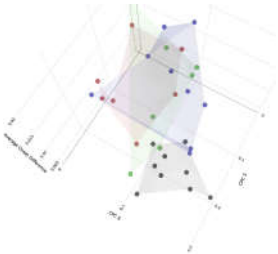
Motor Bike Sounds / 摩托车声音 (Czedik-Eysenberg, Knauf, Reuter 2015)



Audio Logos / 音频标志 (Czedik-Eysenberg, Anzenbacher, Reuter, Oehler 2014)



HipHop Producers / 嘻哈音乐制作人 (Kudakov, Reuter 2021)



Early Jazz Trumpeters / 早期爵士小号手 (Williams, Reuter 2023)

Systematic Musicology

1 Timbre measurement and more

1.3 Take Home Message (1)

Signal analysis is useful in many ways to make human timbre perception calculable and trace them back to a small set of timbre features.

With PADMEA and other signal analysis libraries, it is possible to create calculable prediction models for nearly any human sound descriptions.

e.g. Musical Hardness consists of a set of timbre features like fast tempo, low dynamic distribution, strong noisyness (lack of clear melodic lines), percussive energy, and rhythmic density.

体系音乐学

1 音色测量等

1.3 带回家的信息 (1)

信号分析在许多方面都很有用, 它能使人类的音色感知变得可计算, 并追溯到一小部分音色特征.

利用 PADMEA 和其他信号分析库, 可以为几乎所有人类声音描述创建可计算的预测模型.

例如, 音乐硬度由一组音色特征组成, 如快节奏, 低动态分布, 强噪音（缺乏清晰的旋律线条）， 打击乐式的能量和节奏密度.

The PhD thesis of Isabella Czedik-Eysenberg („Semantic modelling of perceptual music dimensions on the basis of audio signal features", University of Vienna 2022) has been awarded with the **Award of Excellence of the Federal Ministry of Science, Research and Economics 2022** .
伊莎贝拉-切泽迪克-艾森伯格 (Isabella Czedik-Eysenberg) 的博士论文 ("基于音频信号特征的音乐感知维度语义建模", 2022 年维也纳大学) 荣获 **2022 年联邦科学, 研究和经济部** 颁发的优秀奖.

Systematic Musicology 体系音乐学

2 你从未听过的声音

利用可交换耳叶在 VR 中感知声音

2 Sounds you've never heard before

Perception with Exchangeable Ear Lobes in VR

Systematic Musicology 体系音乐学

2 Sounds you've never heard before

2 你从未听过的声音

2.1 Directional Perception

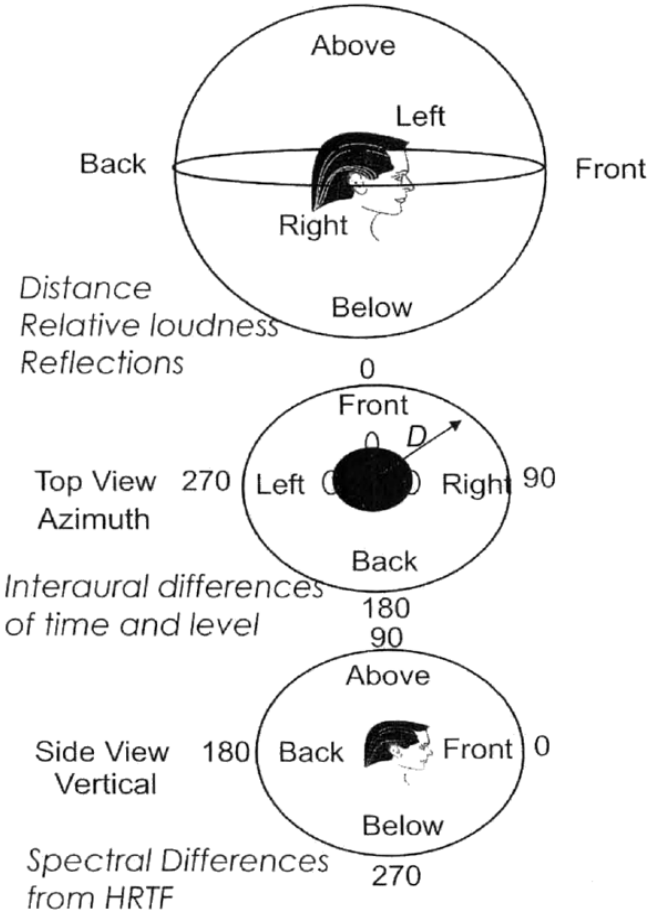
2.1 定向感知

Left-right perception?

左右感知？

Front-back, top-down perception?

前后、上下感知？



Directional Perception / 定向感知 (Yost 2007, p. 174)

Systematic Musicology 体系音乐学

2 Sounds you've never heard before

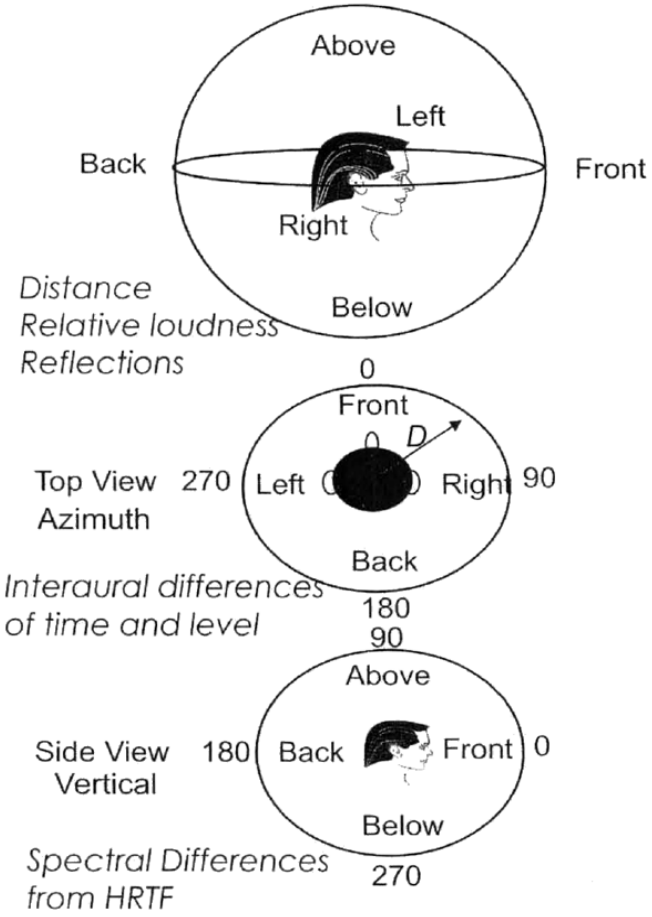
2 你从未听过的声音

2.1 Directional Perception

Left-right perception:

- Low frequencies (below 800 Hz): Time differences between the ears
- High frequencies (above ca. 1600 Hz): Level differences between the ears

Front-back, top-down perception?



Directional Perception / 定向感知 (Yost 2007, p. 174)

2.1 定向感知

左右感知:

- 低频 (低于 800 赫兹): 两耳之间的时间差
- 高频 (约 1600 赫兹以上): 两耳之间的电平差

前后、上下感知？

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2 Sounds you've never heard before

2 你从未听过的声音

2.1 Directional Perception

Left-right perception:

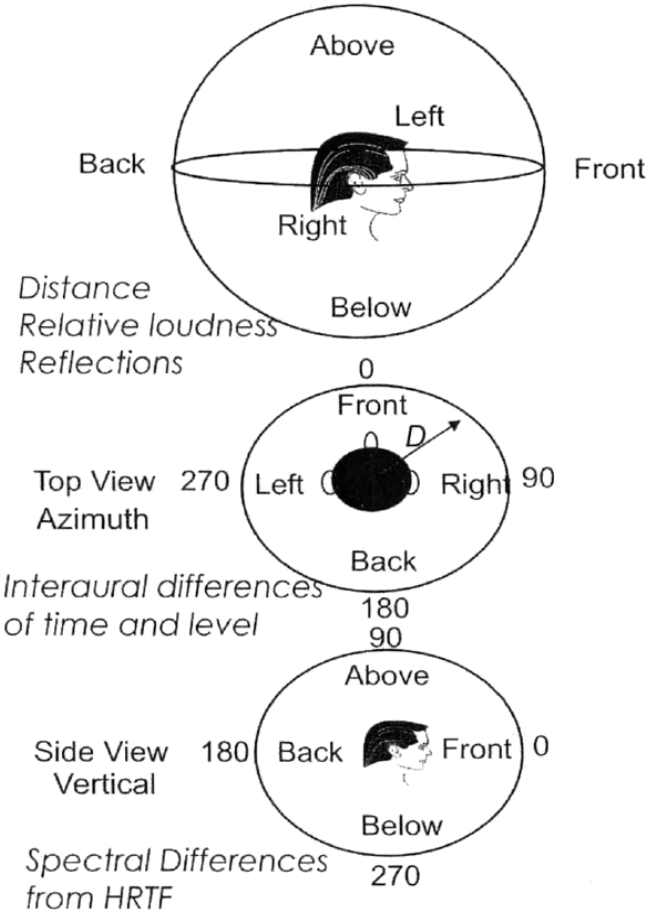
- Low frequencies (below 800 Hz): Time differences between the ears
- High frequencies (above ca. 1600 Hz): Level differences between the ears

Front-back, top-down perception:

Shape of pinna, torso, shoulders leads to individual reflections = individual filter shape

-> Head-Related Transfer Function (HRTF)

HRTF = as individual as a fingerprint absolutely necessary for 360° audio perception



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前后、上下感知:

耳廓, 躯干, 肩部的形状导致因人而异的反射

= 因人而异的滤波器形状

-> 头相关传递函数 (HRTF)

HRTF = 像指纹一样个性化,

是 360° 音频感知的绝对必要条件

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2.2 HRTF Measurement

2.2 HRTF 测量

In VR Environments (Oculus, HTC etc.):
General HRTFs?

在虚拟现实环境中 (Oculus、HTC 等),
通用 HRTFs ?

Individual HRTFs?

个体 HRTFs ?

Typical VR Glasses
典型 VR 眼镜
(HTC VIVE, Oculus Quest)

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2.2 HRTF Measurement

In VR Environments (Oculus, HTC etc.):
General HRTFs: the direction of the auditory event is calculated using the HRTFs of an artificial head microphone (usually KEMAR)

Individual HRTFs?

KEMAR* artificial head microphone
KEMAR* 人工头戴麦克风
(G.R.A.S. 2013)

2.2 HRTF 测量

在虚拟现实环境中 (Oculus, HTC 等),
通用 HRTFs: 使用仿真头型麦克风 (通常为 KEMAR) 的 HRTFs 计算听觉事件的方向

个体 HRTFs ?

(* KEMAR = Knowles Electronics Manikin for Acoustic Research)

(KEMAR = 用于声学研究的 Knowles 电子人体模型

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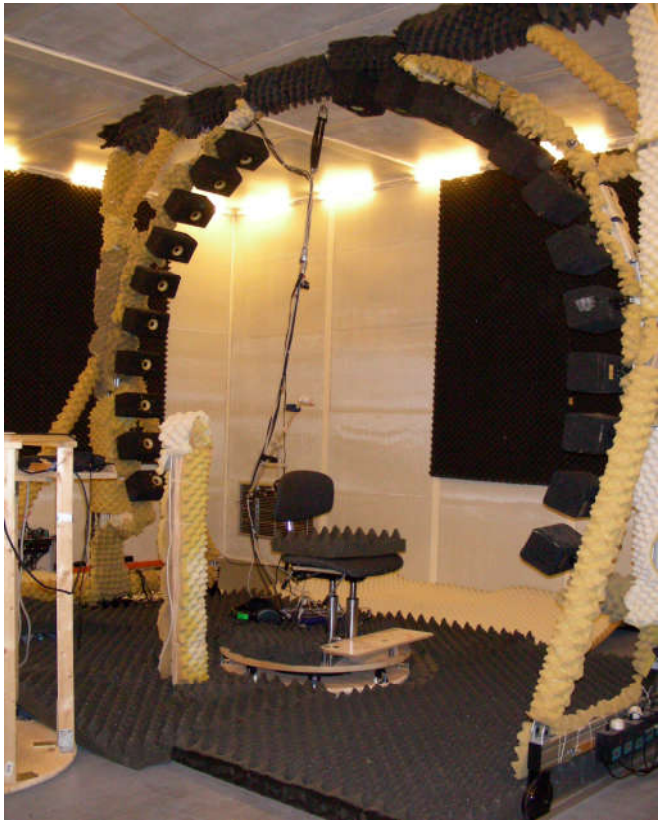
2.2 HRTF Measurement

In VR Environments (Oculus, HTC etc.):
General HRTFs: the direction of the auditory event is calculated using the HRTFs of an artificial head microphone (usually KEMAR)

Individual HRTFs: measured with a vertical circular loudspeaker array generating signals from almost every direction while listener gets rotated on a computer controlled swivel chair.



Loudspeaker Array for HRTF measurements
(Acoustics Research Institute (ARI),
Austrian Academy of Sciences)
用于 HRTF 测量的扬声器阵列
（奥地利科学院声学研究所 (ARI)

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单个 HRTFs: 使用垂直环形扬声器阵列测量, 产生来自几乎所有方向的信号, 同时听者在计算机控制的转椅上旋转.

(*SOFA = Spatially Oriented Format for Acoustics)

(* SOFA = 以空间为导向的声学格式)

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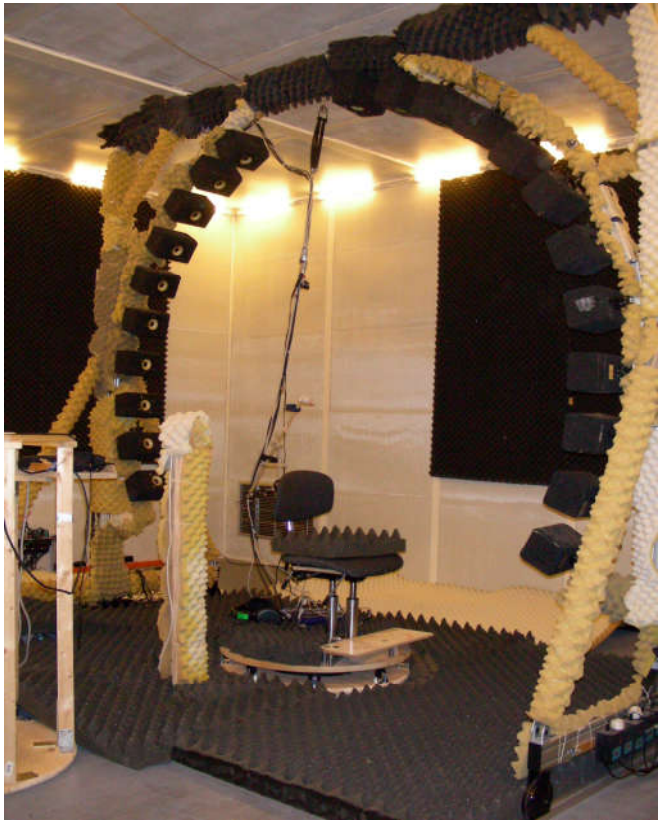
Individual HRTFs: measured with a vertical circular loudspeaker array generating signals from almost every direction while listener gets rotated on a computer controlled swivel chair.

-> ARI HRTF Database with more then 200 listener data in SOFA* Format (with ca. 1500 listener positions each).

(*SOFA = Spatially Oriented Format for Acoustics)



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-> ARI HRTF 数据库, 包含 SOFA* 格式的 200 多个听者数据 (每个听者约有 1500 个位置).

(* SOFA = 以空间为导向的声学格式)

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珍妮, 马伊达克, 路透 2018-2020

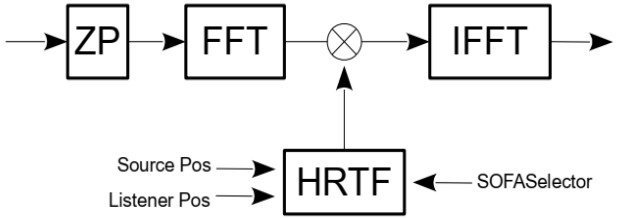
2 Sounds you've never heard before

2 你从未听过的声音

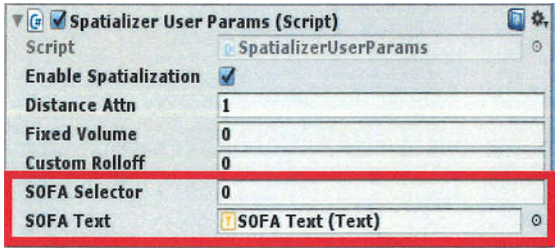
2.3 General vs. Individual HRTFs

As part of her PhD thesis, Claudia Jenny programmed a SOFAlizer plug-in to be able to listen with any ear lobes (= any HRTFs) in a virtual environment, to answer the question:

How big is the difference between general and individual HRTFs?



SOFAlizer fast convolution algorithm using zero-padding (ZP), fast Fourier transform (FFT), and inverse FFT (IFFT)
使用零填充 (ZP), 快速傅立叶变换 (FFT) 和反 FFT (IFFT) 的 SOFAlizer 快速卷积算法 (Jenny 等人 2018年)



Embedding of the SOFAlizer plug-in into Unity 3D Developement Environment
将 SOFAlizer 插件嵌入 Unity 3D 开发环境 (Jenny 2018)

2.3 通用 HRTF 与个体 HRTF

作为博士论文的一部分, 克劳迪娅-珍妮 (Claudia Jenny) 编写了一个 SOFAlizer 插件, 以便能够在虚拟环境中使用任何耳垂 (=任何 HRTF) 进行聆听, 从而回答这个问题:

通用 HRTF 和个体 HRTF 之间的差别有多大?

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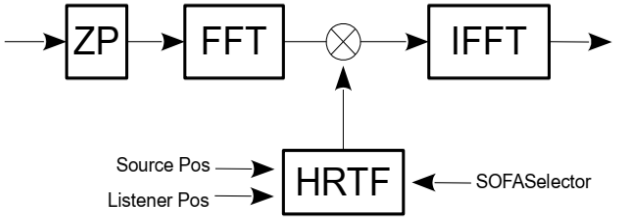
How big is the difference between general and individual HRTFs?

In an artificial 360° environment 39 test persons listened to a drone flying over their heads, and
- choose between their **own** and **KEMAR** HRTFs
- choose between their **own**, a very **similar** and a very **different** HRTF from ARI HRTF database



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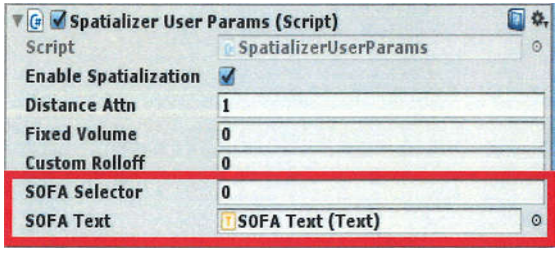

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通用 HRTF 和个体 HRTF 之间的差别有多大?

在人工 360° 环境中, 39 名测试人员聆听了无人机从他们头顶飞过的声音, 以及
- 在自己的HRTF和KEMAR HRTF之间选择
- 在自己的HRTF和ARI HRTF数据库中非常相似和非常不同的HRTF之间做出选择

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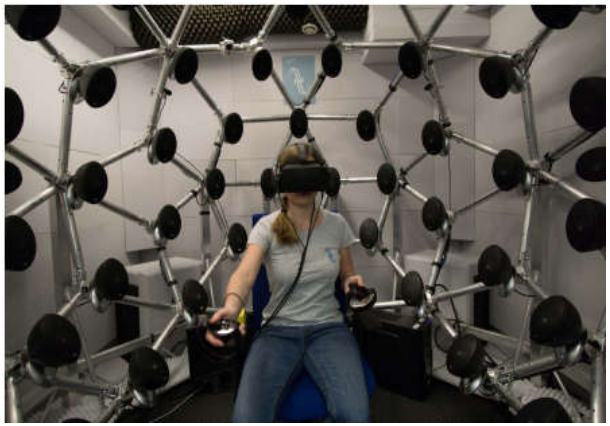
2.3 General vs. Individual HRTFs

Participants had to estimate on a scale from 1-5:

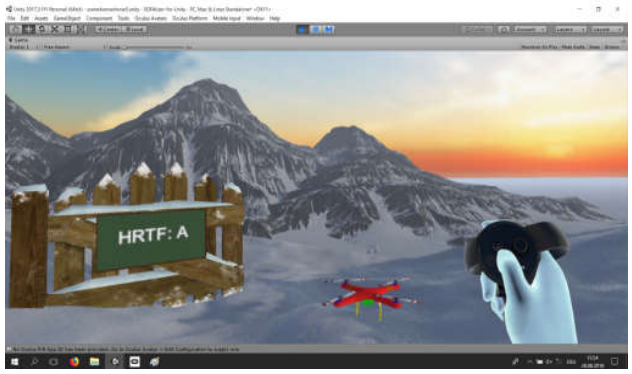
Localizability
very difficult (1) ⟷ very easy (5)

Externalization
very internal (1) ⟷ very external (5)

Realism
nonrealistic (1) ⟷ realistic (5)



Hearing Situation for the test persons (ARI)
(Austrian Academy of Sciences)
测试人员的听力状况
(奥地利科学院声学研究所)



VR Environment with exchangeable HRTFs
可交换 HRTF 的 VR 环境 (Jenny 2018)

2.3 通用 HRTF 与个体 HRTF

参与者需用 1-5 分来估计:

定位
非常困难 (1) ⟷ 非常容易 (5)

内外程度
非常内部 (1) ⟷ 非常外部 (5)

真实程度
不真实 (1) ⟷ 真实 (5)

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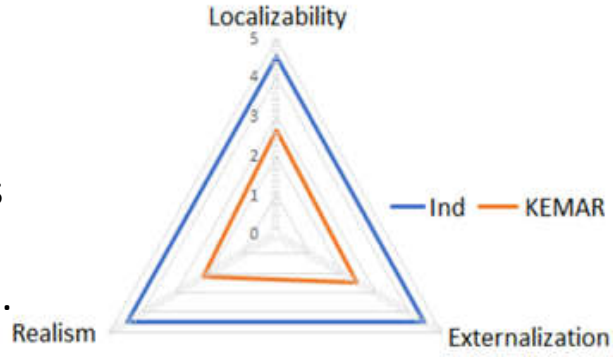
2.4 Results

Unlike the **KEMAR** HRTFs, **individual** HRTFs allow a more realistic listening experience with better localisation and externalisation.

(Wilcoxon signed-rank test: Localizability: *W* = 5569,5***; Externalization: *W* = 5741,5***; Realism: *W* = 6030***; *p*<0,001)



Individual vs. **KEMAR** HRTFs
单个 HRTF **与** **KEMAR** HRTF **的**对比
(Jenny, Reuter 2020)

2.4 结果

与 **KEMAR** HRTFs **不同,** **个体** **HRTFs** **可提供更真**实的听觉体验, **具有更好的定位能力和内外辨**识度

(Wilcoxon **符号秩检验: 本地化:** W = 5569,5***; **内外辨识度:** W = 5741,5***; **逼真度:** W = 6030***; p<0,001)

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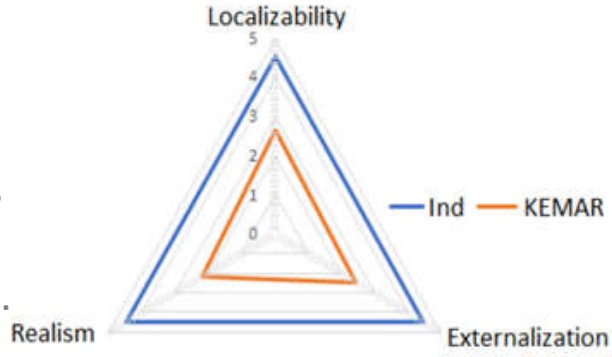
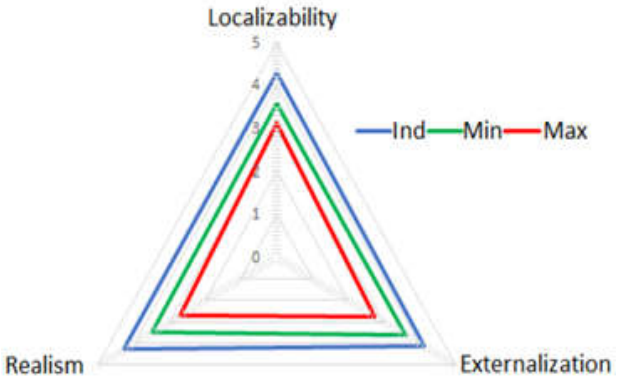


Individual vs. **KEMAR** HRTFs
单个 HRTF **与** **KEMAR** HRTF **的**对比
(Jenny, Reuter 2020)

Individual HRTFs allow a more realistic listening experience with better localisation and externalisation than **minimally deviated** HRTFs.
Maximally deviated HRTFs lead to the most unrealistic listening experience with the worst localisation and externalisation.

(ANOVA: Localizability: *F* = 19,1***; Externalization: *F* = 22,3***; Realism: *F* = 31,9***; *p*<0,001)



单个与**最小**和**最大**偏差 HRTF
Individual vs. **minimal** and **maximal** deviant HRTFs (Jenny, Reuter 2020)

2.4 结果

与 **KEMAR** HRTFs 不同, **个体 HRTFs** 可提供更真实的听觉体验, **具有更好的定位能力和内外辨识度**

(Wilcoxon **符号秩检验**: **定位能力**: W = 5569,5***; **内外辨识度**: W = 5741,5***; **逼真度**: W = 6030***; p<0,001)

与最小偏差的 HRTF **相比**, **个体** HRTF **能带来更真实的听觉体验, 具有更好的定位和外化效果.**
最大偏差的 HRTF **会**带来最不真实的听觉体验, **定位能力和内外辨识度最差**

(**方差分析**: **定位能力**: F = 19,1***;**内外辨识度**: F = 22,3***; **逼真度**: F = 31,9***; p<0,001)

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2 Sounds you've never heard before

2.5 Take Home Message (2)

Localization in 360° directional hearing works better with individual HRTFs instead of the general HRTFs mostly used in VR environments.

Furthermore, individual HRTFs are important for the impression of realism, externalization and the localisation of sound source perception.

The PhD thesis of Claudia Jenny („Individual auditory perception in virtual reality - The influence of individualized binaural presentation on the perceived realism in audiovisual virtual environments", University of Vienna 2019) has been awarded with **the Award of Excellence of the Federal Ministry of Science, Research and Economics 2019** (BMWFW)).

Felix Klooss was able to develop a **measuring robot for HRTFs** in his master's thesis "Construction and validation of a robot for measuring HRTFs" 2022, which is cheaper, smaller, more robust and more accurate than previous measuring options. He is currently **patenting** his invention together with the University of Vienna.

体系音乐学

2 你从未听过的声音

2.5 带回家的信息 (2)

在 360° 定向听觉中, 使用**个体 HRTFs** 而不是 VR 环境中常用的通用 HRTFs 可以更好地进行定位.

此外, 单个 HRTF 对于真实感, 内外辨识度和**声源感知的定位也很重要**.

克劳迪娅-珍妮 (Claudia Jenny) 的博士论文 ("虚拟现实中的个人听觉感知--个性化双耳呈现对视听虚拟环境中感知真实度的影响", 维也纳大学, 2019年) 荣获 2019 **年联邦科学, 研究和经济部优秀奖.**

Felix Klooss 在其 2022 年硕士论文 **HRTFs 测量机器人的构建与**验证 "中开发了一种 HRTFs 测量机器人, 与以往的测量方案相比, 该机器人更便宜, 更小巧, 更坚固, 更精确. 目前, 他正在与维也纳大学一**起为自己的发明申请专利**.

3 生活在盒子里

新生儿重症监护室 (NICU) 中的噪音暴露

3 Living in a Box

Noise Exposure in a Neonatal Intensive Care Unit (NICU)

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3 Living in a Box

3 生活在盒子里

3.1 Acoustical Situation in NICU

2-10% of premature babies suffer from hearing impairment or hearing loss (normal population: 0.1%, Wroblewska-Seniuk et al. 2017).

Dräger Isolette 8000 Incubator / 培养箱

3.1 NICU 室内声学状况

2-10%的早产儿患有听力障碍或听力损失 (正常人群: 0.1%, Wroblewska-Seniuk 等人, 2017 年).

(* AAP* = American Academy of Pediatrics, NICU = Neonatal Intensive Care unit)

(AAP* = 美国儿科学会, NICU = 新生儿重症监护室)

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3 Living in a Box

3 生活在盒子里

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Nearly 50% of preterm babies suffer from deficits in language acquisition at the age of three (Foster-Cohen et al. 2007; Ribeiro et al. 2011)

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近 50%的早产儿在三岁时出现语言学习障碍 (Foster-Cohen 等人, 2007 年; Ribeiro 等人, 2011 年)

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The noise level in incubators is usually much higher than the 45 dB recommended by AAP* (1997). Usually, the idle level is about 57 dB. It rises to a peak level of 82-117 dB while handling/opening the box.

(* AAP* = American Academy of Pediatrics, NICU = Neonatal Intensive Care unit)

Dräger Isolette 8000 Incubator / 培养箱

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3 生活在盒子里

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培养箱中的噪音水平通常远高于 AAP* (1997 年) 建议的 45 分贝.

通常, 空闲时的噪音水平约为 57 分贝. 在处理/打开箱体时, 噪音会上升到 82-117 分贝的峰值水平.

(AAP* = 美国儿科学会, NICU = 新生儿重症监护室)

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3 Living in a Box

3 生活在盒子里

•3.1 Acoustical Situation in NICU

• high internal noise level, especially at high frequencies during air supply

In the womb: about 57 dB idle level on low frequencies (Satt 1987)

The acoustic situation in an incubator is very different from that in the womb

培养箱内的声学环境与子宫内的声学环境截然不同

(Phelan, Satt 1987)

3.1 NICU 室内声学状况

- 内部噪音大, 尤其是送风时的高频噪音

在子宫内: 低频闲置水平约为 57 分贝 (Satt, 1987 年)

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3 Living in a Box

3 生活在盒子里

•3.1 Acoustical Situation in NICU

• high internal noise level, especially at high frequencies during air supply
In the womb: about 57 dB idle level on low frequencies (Satt 1987)

• Insulation of external noise. Voices etc. from outside are difficult to perceive
In the womb: below 300 Hz: Sound transmission as in air, above 300 Hz: damping by 5dB/Oct. (Voices are good to perceive, Abrams 1998)

The acoustic situation in an incubator is very different from that in the womb
培养箱内的声学环境与子宫内的声学环境截然不同
(Phelan, Satt 1987)

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- 内部噪音大, 尤其是送风时的高频噪音
在子宫内: 低频闲置水平约为 57 分贝 (Satt, 1987 年)

- 隔绝外部噪音。语音等外部声音难以感知
在子宫内: 低于 300 赫兹: 声音传播与空气中一样, 高于 300 赫兹: 阻尼为 5 分贝/10 月 (声音易于感知, Abrams, 1998 年)

Systematic Musicology 体系音乐学

3 Living in a Box

3 生活在盒子里

•3.1 Acoustical Situation in NICU

• high internal noise level, especially at high frequencies during air supply
In the womb: about 57 dB idle level on low frequencies (Satt 1987)

• Insulation of external noise. Voices etc. from outside are difficult to perceive
In the womb: below 300 Hz: Sound transmission as in air, above 300 Hz: damping by 5db/Oct. (Voices are good to perceive, Abrams 1998)

• high structure-borne sound: contacts with the walls (knocking, medical devices, doors) get acoustically strongly amplified
In the womb: only the mothers voice is amplified by structure-borne sound

The acoustic situation in an incubator is very different from that in the womb
培养箱内的声学环境与子宫内的声学环境截然不同
(Phelan, Satt 1987)

3.1 NICU 室内声学状况

- 内部噪音大, 尤其是送风时的高频噪音
在子宫内: 低频闲置水平约为 57 分贝 (Satt, 1987 年)
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- 高结构传播声音: 与墙壁接触的声音 (敲击声, 医疗器械声, 门声) 会被强烈放大.
在子宫里: 只有母亲的声音会被结构传播的声音放大

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3 Living in a Box

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• high structure-borne sound: contacts with the walls (knocking, medical devices, doors) get acoustically strongly amplified
In the womb: only the mothers voice is amplified by structure-borne sound

• Cavity = must have resonances (at low frequencies)
In the womb: resonances over 10 kHz have been calculated, have no impact (Diwan et al. 2019)

The acoustic situation in an incubator is very different from that in the womb
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在子宫里: 只有母亲的声音会被结构传播的声音放大

• 空腔 = 有共振 (低频)
在子宫内: 已计算出超过 10 千赫的共振, 但没有影响 (Diwan 等人, 2019 年)

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Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

3 生活在盒子里

3.2 Noise Measurement Setup

Incubator (Dräger Isolette C2000) with a soft bedded SimCharacter Paul (corresponding to a 7 month old preterm).

Measurement Microphones (Esper K4) have been placed outside and inside the Incubator.

Infant Flow (CareFusion) Respiratory System
婴儿流（CareFusion）呼吸系统

3.2 噪声测量设置

培养箱 (Dräger Isolette C2000) 中软床上的 SimCharacter Paul (相当于 7 个月大的早产儿).

测量麦克风 (Esper K4) 放置在培养箱内外.

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Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

3 生活在盒子里

3.2 Noise Measurement Setup

Incubator (Dräger Isolette C2000) with a soft bedded SimCharacter Paul (corresponding to a 7 month old preterm).

Measurement Microphones (Esper K4) have been placed outside and inside the Incubator.

Everyday noises were measured:
- Incubator environment
- Incubator handling
- Respiration Support inside Incubator in dB_A and dB_{SPL}

Infant Flow (CareFusion) Respiratory System
婴儿流（CareFusion）呼吸系统

3.2 噪声测量设置

培养箱 (Dräger Isolette C2000) 中软床上的 SimCharacter Paul (相当于 7 个月大的早产儿).

测量麦克风 (Esper K4) 放置在培养箱内外.

对日常噪音进行了测量：
- 培养箱环境
- 培养箱操作
- 培养箱内的呼吸支持, 单位为 dB_A 和 dB_{SPL}

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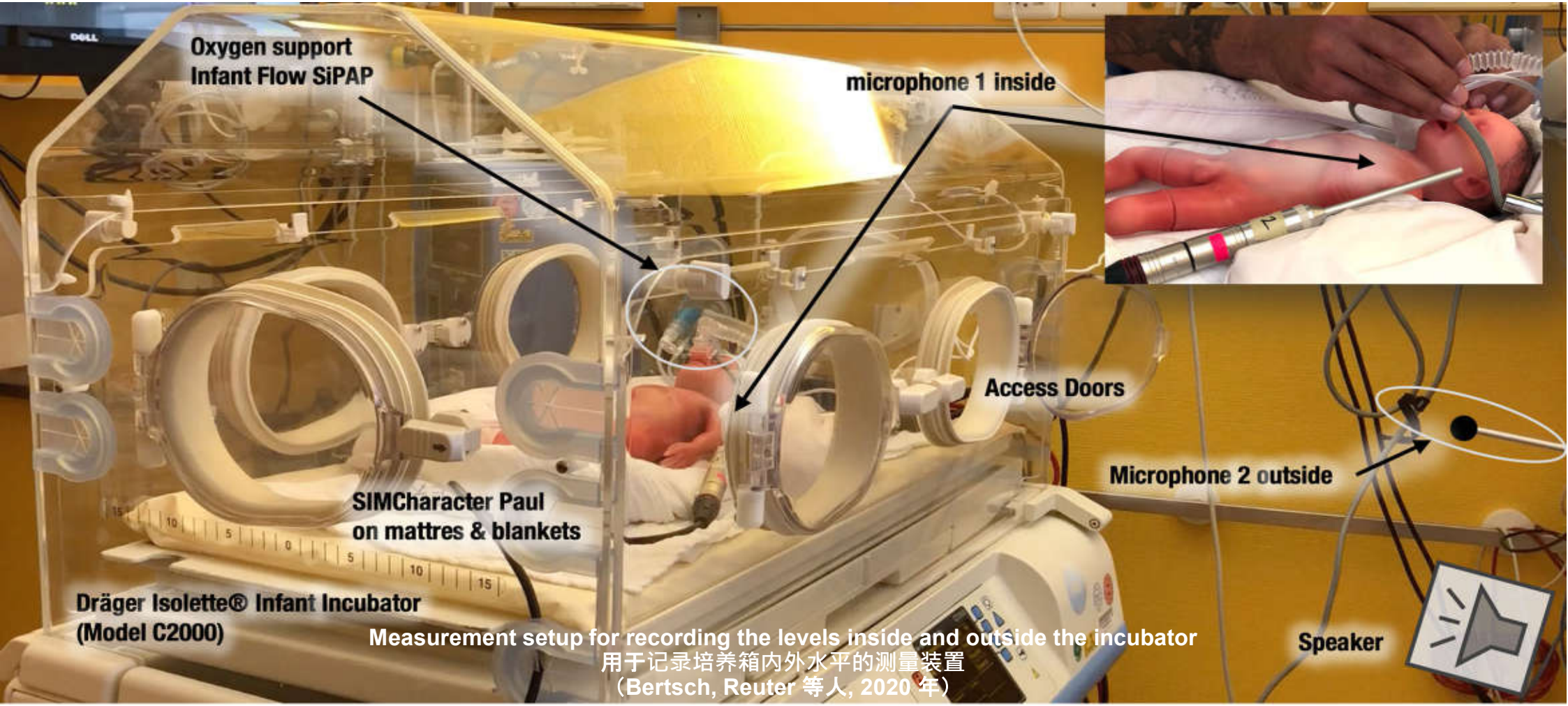
3 生活在盒子里



Measurement setup for recording the levels inside and outside the incubator
用于记录培养箱内外水平的测量装置
（Bertsch, Reuter 等人, 2020 年）

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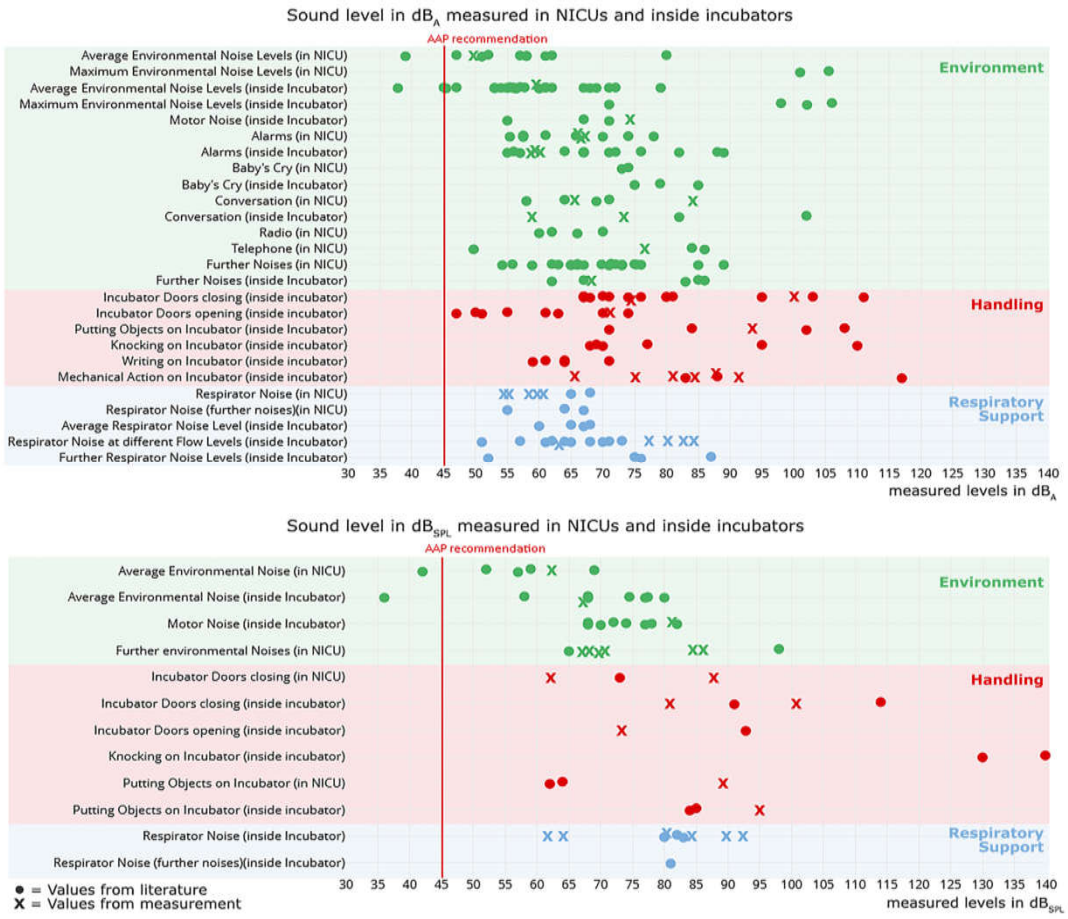
3.3 Results

- There are far more measurements in dB_A than in dB_{SPL} In literature.
- Measured levels in dB_A are lower than in dB_{SPL}
- The loudest levels occur when handling the incubator and during respiration support.

3 生活在盒子里



Level measurements in dB_A and dB_{SPL} in comparison
以 dB_A 和 dB_{SPL} 为单位的电平测量值对比 (Reuter 等人, 2023 年)

3.3 结果

- **文献中以** dB_A 为单位的测量值远远多于以 dB_{SPL} 为单位的测量值.
- **以** dB_A 为单位的测量值**低于以** dB_{SPL} 为单位的测量值
- **最大声出**现在操作培养**箱和呼吸支持**时

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Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

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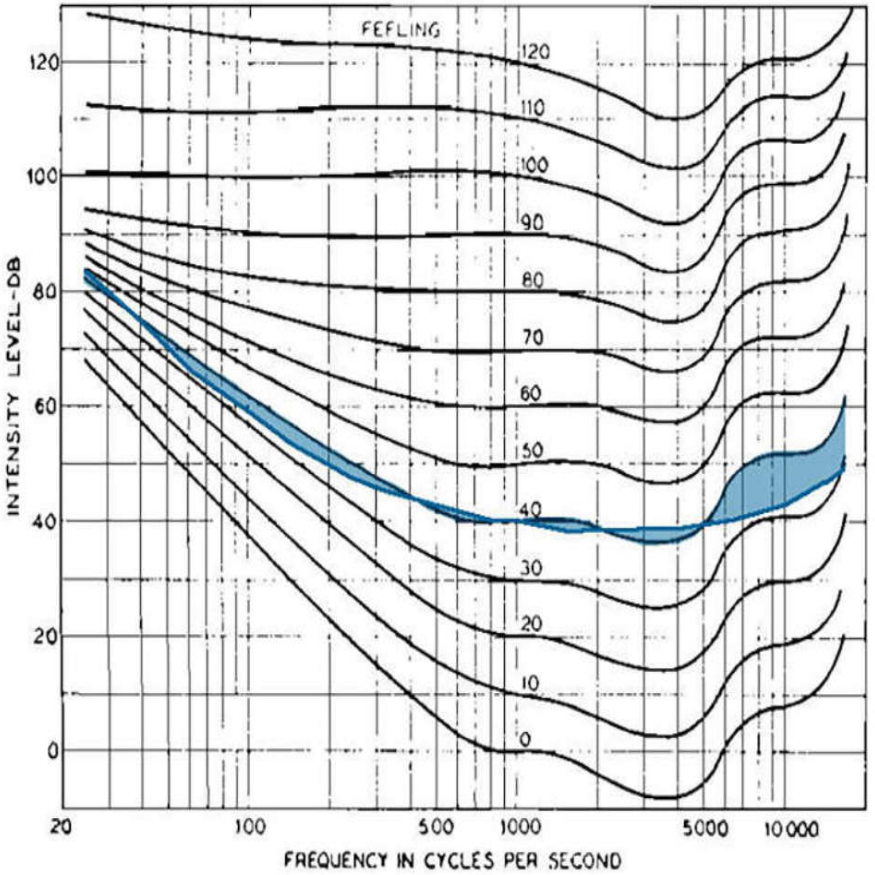
3.3 Results

3.3 结果

dB_A is meaningless here, because:

- The hearing threshold of newborns is different from that of adults (dip at 6-7 kHz instead of 3-4 kHz)
- dB_A is optimised for low levels, not for medium to high levels.
- Amplitudes of low and high frequencies are underrepresented at dB_A.
  -> Incubator resonance (low frequencies)
  -> Respiration support (high frequencies)



Curves of equal loudness compared to the dB_A curve
与 dB_A 曲线相比, 响度相同的曲线
(根据 Fletcher, Munson 1933 年, 第 91 页)

dB_A 在这里毫无意义, 因为:

- 新生儿的听力阈值与成人不同 (在 6-7 千赫而不是 3-4 千赫时下降)
- dB_A 是针对低音量而非中高音量进行优化的.
- 低频和高频的振幅在dB_A上的代表性不足.
  -> 培养箱共振（低频）
  -> 呼吸支持（高频）

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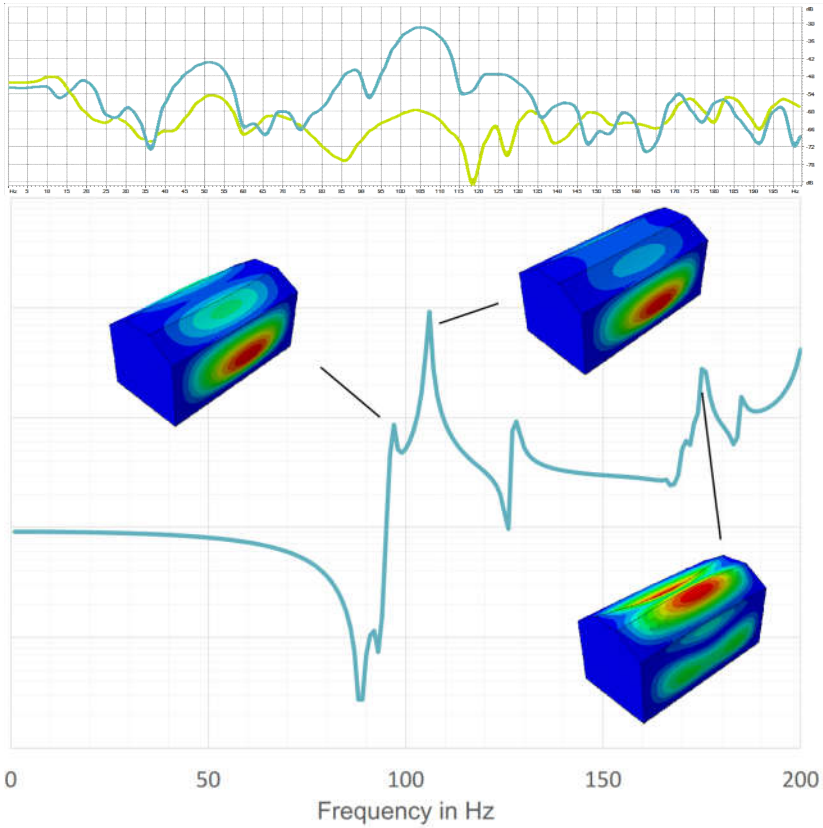
3 Living in a Box

3 生活在盒子里

3.3 Results

The Dräger Isolette 8000 incubator has a main resonance at 97 Hz. This is where a 28 dB amplification of the sound takes place.

Spectrum of the excitation pulse
Spectrum of the impulse response



Measured (top) and simulated (bottom) resonance properties of the incubator
培养箱的测量（上）和模拟（下）共振特性
(Reuter 等人, 2023 年, 第 8 页)

3.3 结果

Dräger Isolette 8000 培养箱的主要共振频率为 97 赫兹. 在此位置, 声音可放大 28 dB.

激励脉冲频谱
脉冲响应频谱

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Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

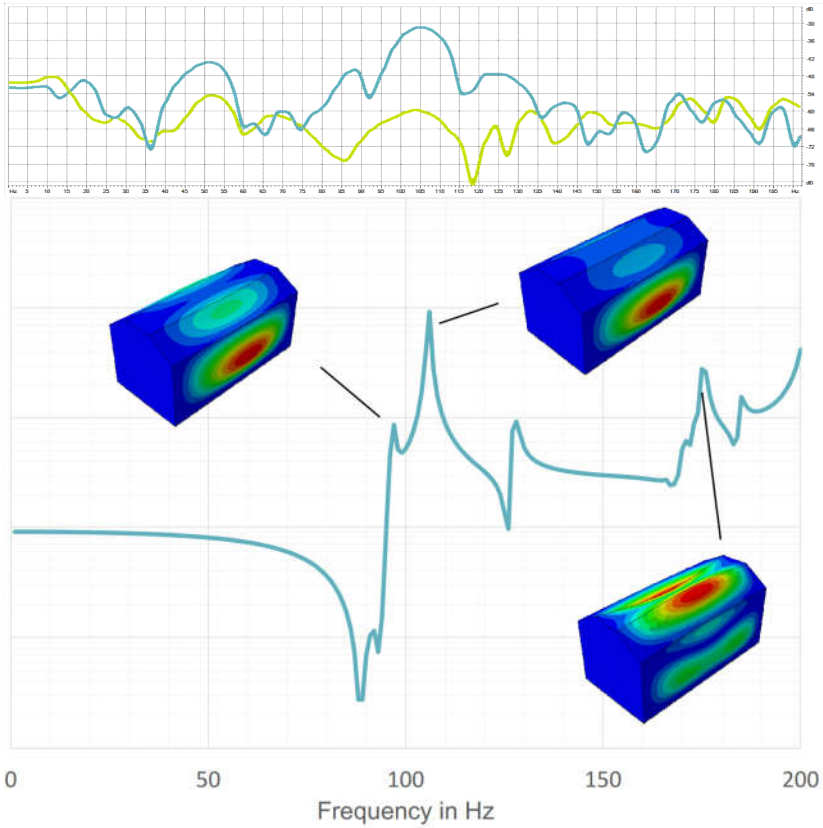
3 生活在盒子里

3.3 Results

The Dräger Isolette 8000 incubator has a main resonance at 97 Hz. This is where a 28 dB amplification of the sound takes place.

—— Spectrum of the excitation pulse
—— Spectrum of the impulse response

This main resonance can be found in the real measurement as well as in the numerical simulation of the incubator box



Measured (top) and simulated (bottom) resonance properties of the incubator
培养箱的测量（上）和模拟（下）共振特性
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—— 激励脉冲频谱
—— 脉冲响应频谱

在实际测量和培养箱的数值模拟中都能发现这一主要共振现象

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Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

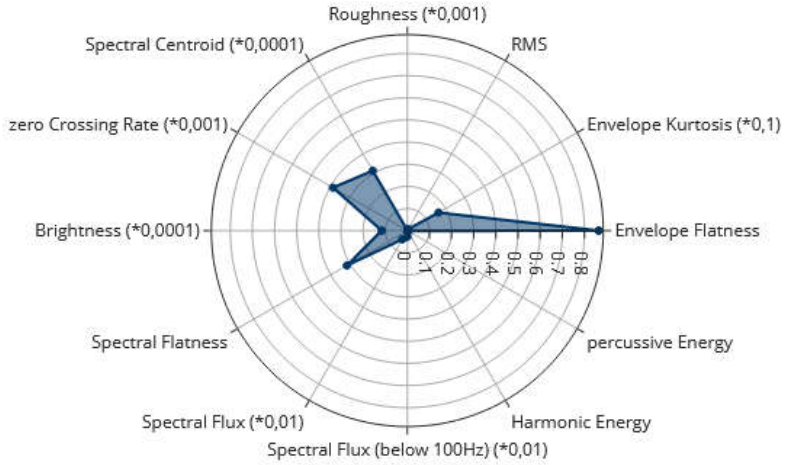
3 生活在盒子里

3.3 Results

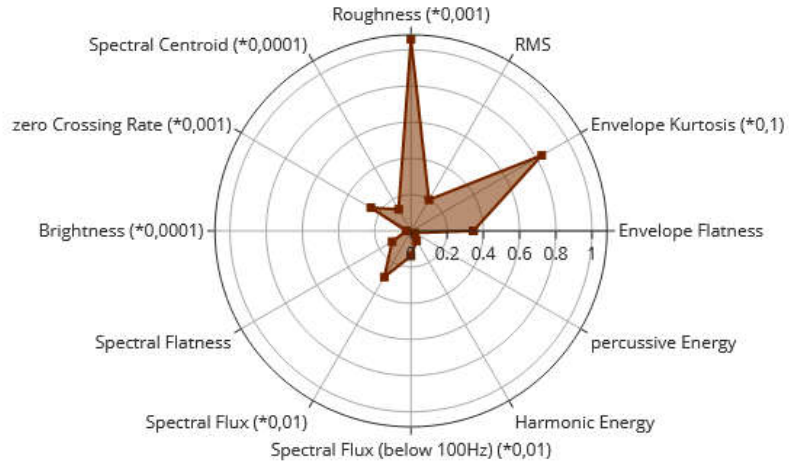
3.3 结果

Structure-borne sound:
Short noises generated on the outside of the incubator walls reach an amplification of approx. ca. 20 dB inside the incubator.

结构传播的声音:
培养箱外壁产生的短促噪音在培**养箱内会放大**约 20 dB.



Routine medical procedures:
Blood pressure gauge placed on incubator
outside: 62 dB, inside: 84 dB
Kidney shell placed on incubator
outside: 64 dB, inside: 85 dB
Closing incubator doors
outside: 73 dB, inside: 91 dB



常规医疗程序:
在培养箱上放置血压计
外部: 62 dB, 内部: 84 dB
将肾脏外壳放在培养箱中
外部: 64 dB, 内部: 85 dB
关闭培养箱大门
外部: 73 dB, 内部: 91 dB

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体系音乐学

Bertsch, 奇泽迪克-艾森伯格, Bartha-Doering, Giordano, 路透社 自 2020 年至 2023 年

3 Living in a Box

3 生活在盒子里

3.4 Take Home Message (3)

- It is rarely quieter than 45 dB in an incubator.
- Strong noise sources are respiration support (up to 93 dB) and the doors (up to 101 dB)
- Structure-borne sound amplifies the sound level inside the incubator by about 20 dB.
- The incubator has a strong self-resonance at about 100 Hz (amplification by 28 dB).
- For noise ratings dB_{SPL} should be used instead of dB_A.

3.4带回家的信息 (3)

- 培养箱中的噪音很少低于 45 dB.
- 强噪声源是呼吸支持 (高达 93 dB) 和门 (高达 101 dB).
- 结构传播的声音会将培养箱内的声级放大约 20 dB.
- 培养箱在大约 100 Hz 时会产生强烈的自共振 (放大 28 dB).
- 对于噪音等级, 应使用 dB_{SPL} 而不是 $dB_{A.}$

Bertsch, M., Reuter, C., Czedik-Eysenberg, I., Berger, A., Olischar, M., Bartha-Doering, L. and Giordano, V. (2020). The "Sound of Silence" in a Neonatal Intensive Care Unit-Listening to Speech and Music inside an Incubator. *Frontiers in Psychology 11:1055*. doi: 10.3389/fpsyg.2020.01055

Reuter, C., Bartha-Doering, L, Czedik-Eysenberg, I., Maeder, M., Bertsch, M., Bibl, K., Deindl, P., Berger, A., Giordano, V. (2023). Living in a box: Understanding acoustic parameters in the NICU environment. *Frontiers in Pediatrics 11*:1147226 doi: 10.3389/fped.2023.1147226

4 岩石上的寒意

醉酒时音乐引起的鸡皮疙瘩（寒冷效应）

4 Chilling on the Rocks

Music-induced Goosebumps (Chill Effect) while being drunk

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4 Chilling on the rocks

4 岩石上的寒意

When emotionally aroused by music: pores open, we sweat more and skin conductivity increases.
In certain emotionally particularly moving parts: goose bumps (chills).

当情绪被音乐唤起时: **毛孔**张开, **出汗增多**, **皮肤**导电性增强.
在某些情绪**特**别激动的段落: **起**鸡皮疙瘩 (发冷).

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4 Chilling on the rocks

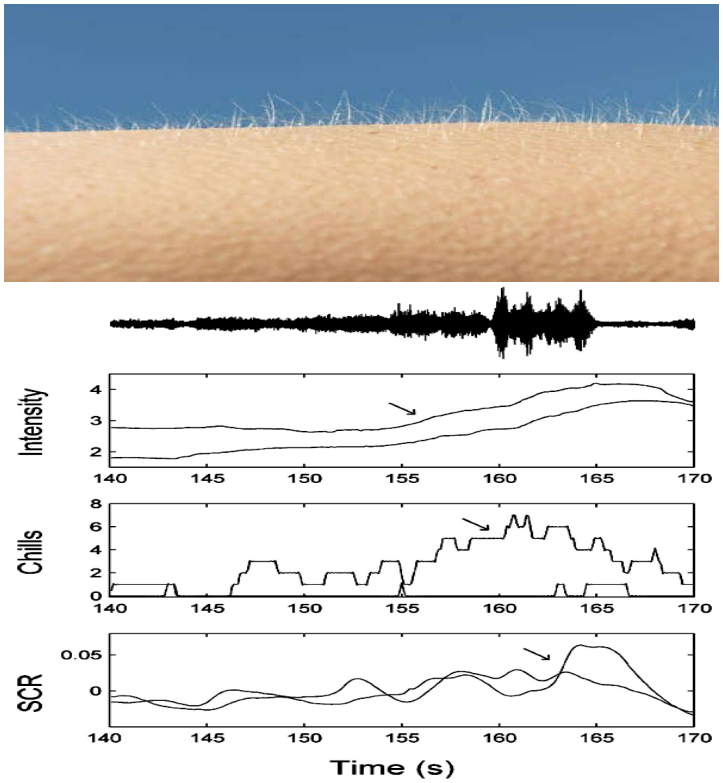
4 岩石上的寒意

When emotionally aroused by music: pores open, we sweat more and skin conductivity increases.
In certain emotionally particularly moving parts: goose bumps (chills).

- Limbic system is activated
- Endorphins are released
- Hairs straighten up.

Cortex areas for preferences, experiences as well as personality traits are partly responsible for this effect.

Songs that have a high goosebump factor are often more popular.



Emotional reactions (intensity), number of chills and skin conductance during an excerpt from Verdi's Requiem
威尔第《安魂曲》选段中的情绪反应 (强度), 寒颤次数和皮肤电导率 (SCR)
(Grewe, Kopiez, Altenmüller, 2009 年, 第 67 页)

当情绪被音乐唤起时: 毛孔张开, 出汗增多, 皮肤导电性增强.
在某些情绪特别激动的段落: 起鸡皮疙瘩 (发冷).

- 激活边缘系统
- 释放内啡肽
- 头发竖直

大脑皮层中的偏好, 经验和个性特征是造成这种效果的部分原因.

令人起鸡皮疙瘩的歌曲往往更受欢迎.

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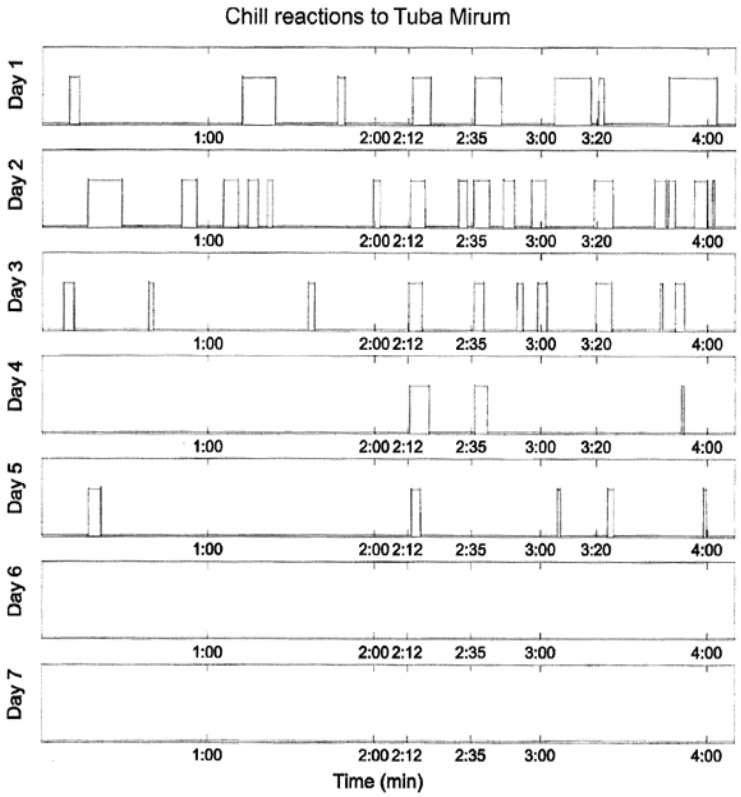
4 Chilling on the rocks

Goosebumps can be caused especially by abrupt or unexpected changes in music, such as:

- Sudden harmonic changes (regressions, fallacies, secondary keys)
- Sudden changes in timbre (starting new voices or instruments, sudden solos or tutti)
- Sudden dynamic changes (crescendi, *fff*, *ppp*)
- meaningful words in the song lyrics (like “friendship”, “love”, “home“, “mother” etc.).

4 岩石上的寒意



Chills of a test subject when listening several times to "Tuba Mirum”
多次聆听 "Tuba Mirum "时, 一名受试者起鸡皮疙瘩
(Grewe 等人, 2007 年, 第 305 页)

音乐中突然或意想不到的变化尤其会引起起鸡皮疙瘩, 例如

- 突然的和声变化 (反向进行, 意外进行, 转调)
- 音色的突然变化 (开始演奏新的声部或乐器, 突然的独奏或重奏)
- 突然的动态变化 (渐强, *fff*, *ppp*)
- 歌词中含义丰富的词语 (如 "友谊", "爱", "家", "母亲“ 等).

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斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

4 岩石上的寒意

Does the consumption of alcohol increase the goosebump feeling when listening to music?

Is “Music + Vodka the strongest form of Magic”?
音乐+伏特加是最强的魔法"？

在听音乐时, 饮酒是否会增加起鸡皮疙瘩的感觉？

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斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

Does the consumption of alcohol increase the goosebump feeling when listening to music?

Crossover test design with measurement repetition: 39 subjects listened to two pieces of music with an interval of two weeks:
Chill song = chosen by the participant
Control song = "What a wonderful world", sung/played by Eva Cassidy

4 岩石上的寒意

How high is the chilling sky?
寒冷的天空有多高？

在听音乐时, 饮酒是否会增加起鸡皮疙瘩的感觉？

采用重复测量的交叉测试设计:
39 名受试者聆听了两首音乐, 间隔时间为两周:
放松歌曲 = 由受试者选择
对照歌曲 = 由伊娃-卡西迪演唱/演奏的《世界真美好》

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4 岩石上的寒意

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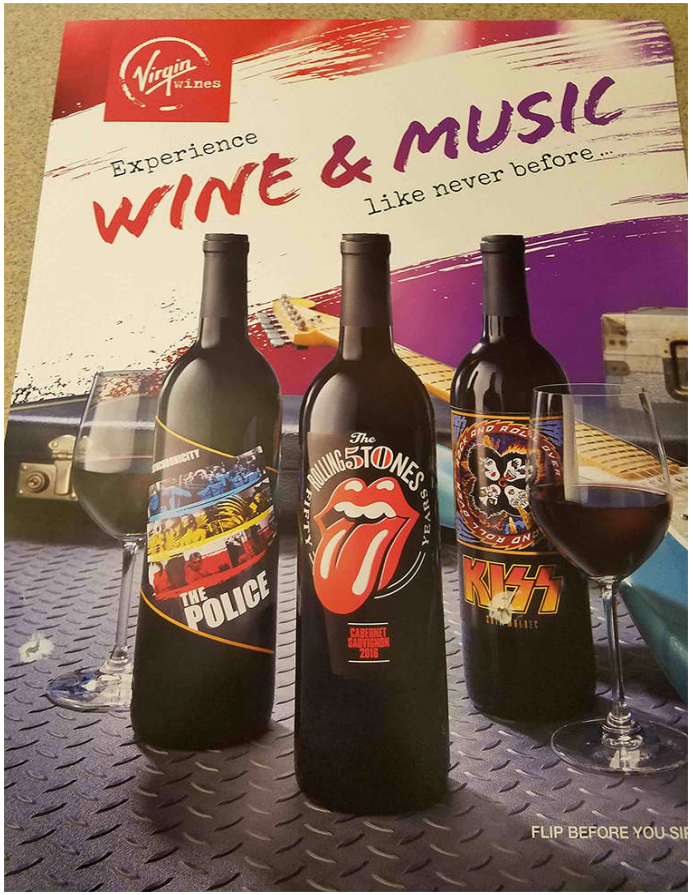
Group **1** started sober, group **2** slightly alcoholised (0,4 – 1,5‰).
Two weeks later:
group **2** started sober, group **1** slightly alcoholised.



Does wine & music increase the music-induced chill effect?
葡萄酒和音乐会增加音乐引起的寒意效应吗？

在听音乐时, 饮酒是否会增加起鸡皮疙瘩的感觉？

采用重复测量的交叉测试设计:
39 名受试者聆听了两首音乐, 间隔时间为两周:
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第一组开始戒酒, 第二组轻微酗酒 (0.4 - 1.5‰).
两周后:
第二组开始戒酒, 第一组轻微酗酒.

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斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

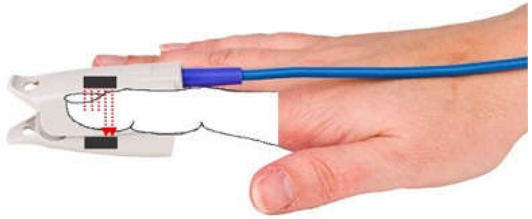
For each goosebump feeling, the subjects were asked to press a button while their skin conductance, blood pressure and heart rate were recorded in sync with the music by a biodata logger (MindMedia Nexus 10MKII).

4 岩石上的寒意

每当受试者有起鸡皮疙瘩**的感**觉时, **他**们都会被要求按**下一个按**钮, **同**时他们的**皮肤**电导率, **血**压和心率**会被生物数据**记录仪 (MindMedia Nexus 10MKII) 记录下来, **与音**乐同**步**.

Dräger Alcotest 7410
(精度: ± 0,05‰)

Skin conductance
皮肤电导率
(MindMedia Nexus 10)



Blood pressure and heart rate / 血压和心率
(MindMedia Nexus 10MKII)

*NEO-FFI = Neuroticism, Extraversion, Openess - Five-Factor-Inventory
*IAAM = Activation and Arousal Modulation through Music

*NEO-FFI = 神经质, 外向性, 开放性--五因素量表
*IAAM = 通过音乐进行激活和唤醒调节

Systematic Musicology 体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

For each goosebump feeling, the subjects were asked to press a button while their skin conductance, blood pressure and heart rate were recorded in sync with the music by a biodata logger (MindMedia Nexus 10MKII).

In addition, the participants filled out two questionnaires before the test:

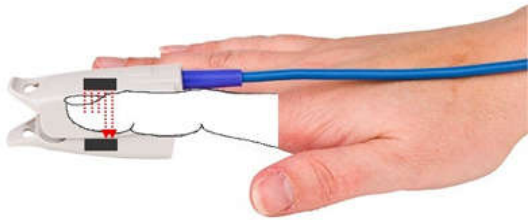
NEO-FFI*: Big Five Personality dimensions
IAAM*: Listening Habits Test

*NEO-FFI = Neuroticism, Extraversion, Openess - Five-Factor-Inventory
*IAAM = Activation and Arousal Modulation through Music

4 岩石上的寒意

Dräger Alcotest 7410
(精度: ± 0,05‰)

Skin conductance
皮肤电导率
(MindMedia Nexus 10)



Blood pressure and heart rate / 血压和心率
(MindMedia Nexus 10MKII)

每当受试者有起鸡皮疙瘩的感觉时, 他们都会被要求按下一个按钮, 同时他们的皮肤电导率, 血压和心率会被生物数据记录仪 (MindMedia Nexus 10MKII) 记录下来, 与音乐同步.

此外, 参与者还在测试前填写了两份问卷:

NEO-FFI*: 大五人格维度

IAAM*: 倾听习惯测试

*NEO-FFI = 神经质, 外向性, 开放性--五因素量表
*IAAM = 通过音乐进行激活和唤醒调节

Systematic Musicology

4 Chilling on the rocks

Results

Most goosebump feelings occurred soberly in the chill song (mean: 8,1), while the control song (especially when drunk) showed the least goosebump moments (mean: 2,33).

体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 岩石上的寒意

结果

大多数起鸡皮疙瘩的感觉发生在清醒时的放松歌曲中 (平均值: 8.1), 而对照歌曲 (尤其是醉酒时) 中起鸡皮疙瘩的时刻最少 (平均值: 2.33).

Systematic Musicology 体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

4 岩石上的寒意

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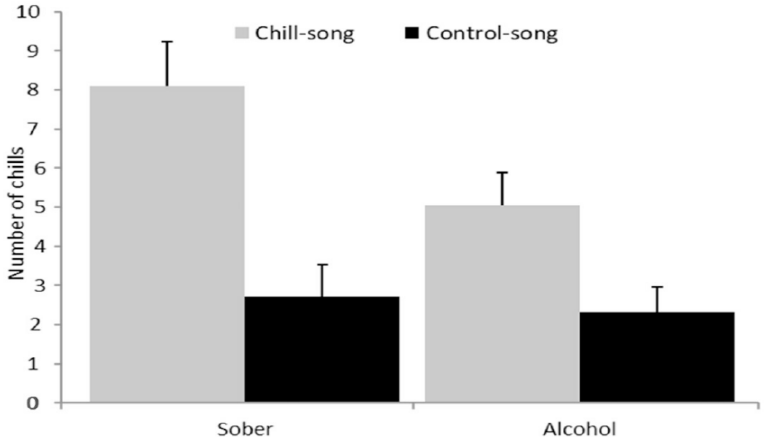
The skin conductance reached a higher level in the sober condition (mean: 5,22 µS resp. 4,30 µS) than when drunk (mean: 2,97 µS resp. 3,94 µS).

清醒状态下的**皮肤**电导率 (平均值: 5.22 µS 或 4.30 µS) **高于醉酒状**态**下的皮肤**电导率 (平均值: 2.97 µS 或 3.94 µS).



Number of goosebumps with and without alcohol
饮酒和不饮酒时的鸡皮疙瘩数量
(Starcke 等人, 2019 年, 第 29 页)

Systematic Musicology 体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

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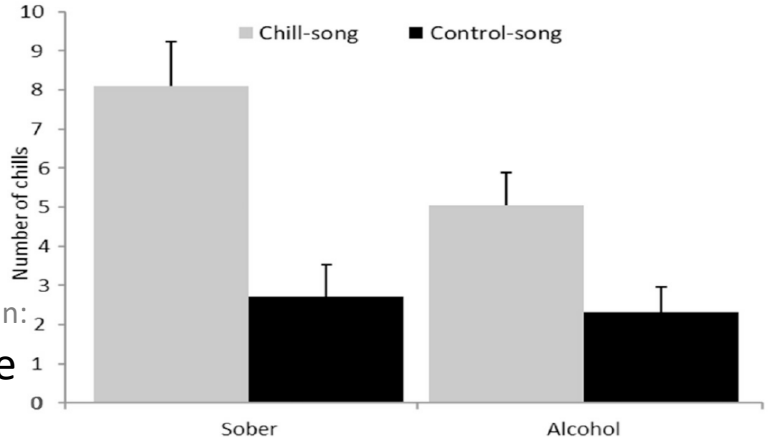
Heart rate tended to be higher (mean: 86 bpm) for the chill song than for the control song (mean: 80-85 bpm).



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清醒状态下的皮肤电导率 (平均值: 5.22 µS 或 4.30 µS) 高于醉酒状态下的皮肤电导率 (平均值: 2.97 µS 或 3.94 µS).

放松歌曲的心率 (平均值: 86 bpm) 往往高于对照歌曲 (平均值: 80-85 bpm).

Systematic Musicology

体系音乐学

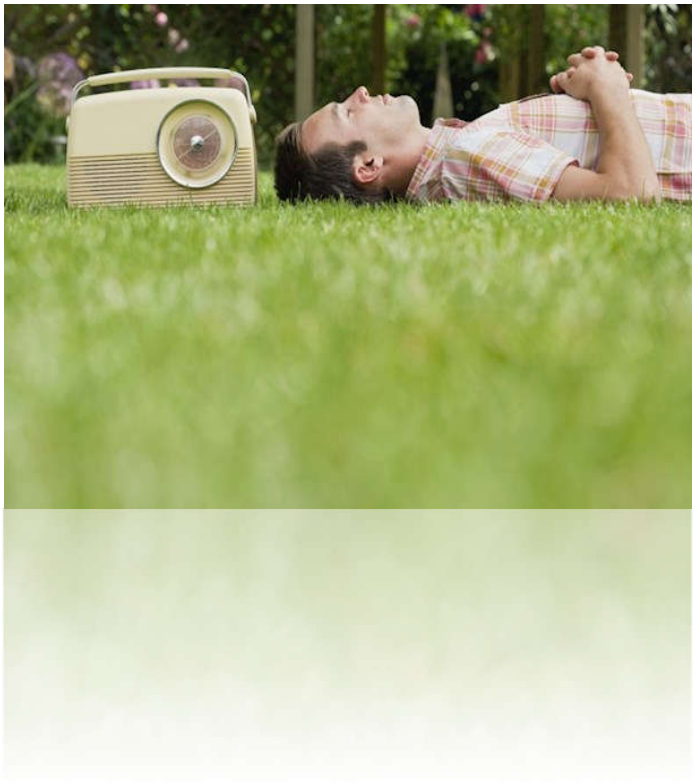
斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

4 岩石上的寒意

Results

IAAM: positive correlation between the number of goosebump moments and music listening habits:
More goosebump feeling when music is used more for relaxation (r=0,44; p<0,01), reduction of negative affect (r=0,48; p<0,005) and arousal modulation (r=0,51: p<0,01 in sober condition).



结果

IAAM: 起鸡皮疙瘩的次数与听音乐**的**习惯呈正相关:
当音乐更多用于**放松** (r=0,44; p<0,01), **减少**负面情绪 (r=0,48; p<0,005) **和**调节唤醒 (r=0,51; 在清醒状态下, p<0,01) 时, **起**鸡**皮疙瘩的感**觉更多.

*NEO-FFI = **神**经质, **外向性, 开放性**--**五因素量表**
*IAAM = **通**过音乐进行激活和唤醒调节

Systematic Musicology

体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

4 岩石上的寒意

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NEO-FFI: positive correlation between skin conductance and openness (control song, r=0,40; p<0,05) and negative correlation between skin conductance/heart rate and extraversion (r=0,5; p<0,01 in sober condition).

结果

IAAM: 起鸡皮疙瘩的次数与听音乐的习惯呈正相关:
当音乐更多用于放松 (r=0,44; p<0,01), 减少负面情绪 (r=0,48; p<0,005) 和调节唤醒 (r=0,51; 在清醒状态下, p<0,01) 时, 起鸡皮疙瘩的感觉更多.

NEO-FFI: 皮肤电导率与开放性呈正相关 (对照组歌曲, r=0,40; p<0,05), 皮肤电导率/心率与外向性呈负相关 (清醒状态下, r=0,5; p<0,01)

*NEO-FFI = 神经质, 外向性, 开放性--五因素量表
*IAAM = 通过音乐进行激活和唤醒调节

Systematic Musicology 体系音乐学

斯塔克, 冯-格奥尔基, 蒂霍宁, 路透, 2019

4 Chilling on the rocks

4 岩石上的寒意

Take Home Message (4)

Alcohol and music-induced goosebumps are perceived as pleasant, but they inhibit each other.

Listeners experience significantly more goosebumps when sober than when drunk (when listening to their own music).

Goosebumps are more intense when sober (higher skin conductance) than when drunk.

Introverts with openness to new experiences have the most intense goosebumps feeling (higher skin conductance, faster heart rate)

Starcke, K., von Georgi, R., Tiihonen, T. M., Laczika, K.-F., & Reuter, C. (2019). Don't drink and chill: Effects of alcohol on subjective and physiological reactions during music listening and their relationships with personality and listening habits. *International Journal of Psychophysiology*, 142, 25–32. https://doi.org/10.1016/j.ijpsycho.2019.06.001

带回家的信息 (4)

酒精和音乐引起的鸡皮疙瘩被认为**是令人愉快的**, **但它**们会相互抑制.

听者在清醒时 (**听自己的音**乐时) **起**鸡皮疙瘩的次数明显多**于醉酒**时.

清醒时**的**鸡皮疙瘩比醉酒时**更强烈** (**皮肤**电导率更高).

对新体验持开放态度的内向者起鸡**皮疙瘩的感**觉最强烈 (**皮肤**电导率**更高, 心率更快**)

Systematic Musicology 体系音乐学

5 探索脚本和软件

进一步的应用和发展

5 Scripts and Software to explore

Further Applications and Developments

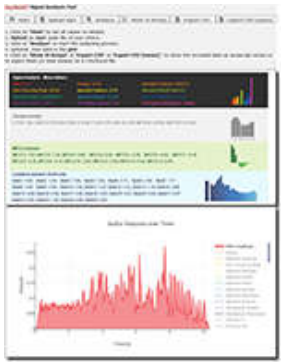
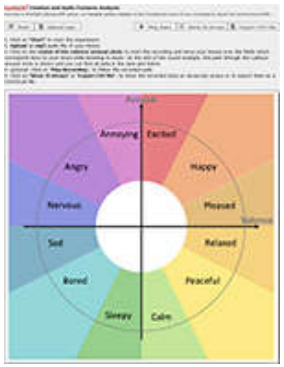
Systematic Musicology 体系音乐学

5 Scripts and Software to explore

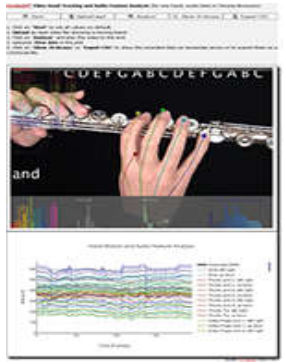
5 脚本和软件探索

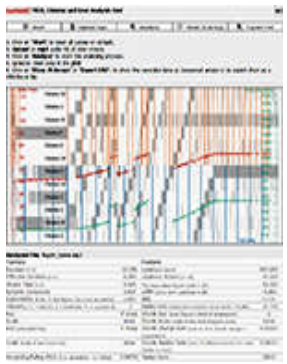
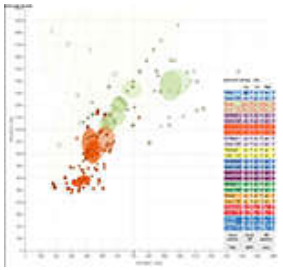
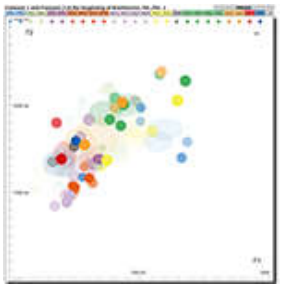
Tools for Data Acquisition and Empirical Research

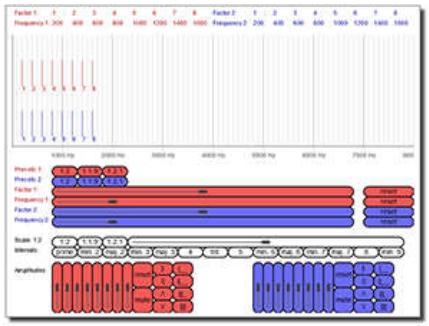
数据采集和实证研究工具







Reuter, C., Czedik-Eysenberg, I., Cui, A.-X. (2023). Happy Life comes with P5 - P5, ML5, Meyda and Plotly as helpful Tools in Teaching and Research. Proceedings of DAGA2023, 49. Conference on Acoustics (p. 991-994). Hamburg.
克里斯托夫·罗伊特, 伊莎贝拉-切泽迪克-艾森伯格, 崔晓星 (2023). 快乐生活与 P5 相伴--P5, ML5, Meyda 和 Plotly 作为教学和研究中的有用工具. DAGA2023, 49. 德国声学年会 (第 991-994 页). 汉堡.

Systematic Musicology

体系音乐学

5 Scripts and Software to explore

5 脚本和软件探索

3DVista Virtual Tours

3DVista offers the ideal software environment for both room acoustic measurements and the virtual processing or documentation of field research or concert visits in 360°/3D/VR.

The images collected with the help of 360°/3D cameras can be linked in a variety of ways and interactively processed with additional audio/video files and texts.

3DVista 虚拟旅游

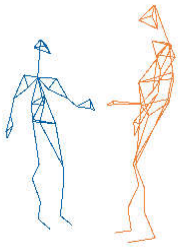
3DVista 提供了理想的软件环境, 既能进行室内声学测量, 又能以 360°/3D/VR 虚拟处理或记录实地研究或音乐会参观.

借助 360°/3D 摄像机收集的图像可以多种方式连接起来, 并与附加音频/视频文件和文本进行交互式处理.

Systematic Musicology 体系音乐学

5 Scripts and Software to explore

5 脚本和软件探索

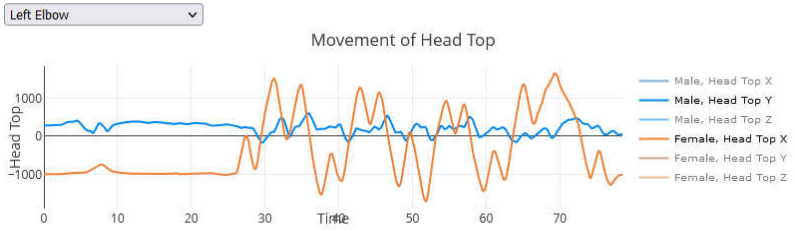


3D Motion Visualisation

3D 运动可视化

JavaScript Framework for recorded MoCap data of the MediaLab:

用于记录媒体实验室 MoCap **数据的** JavaScript **框架**:



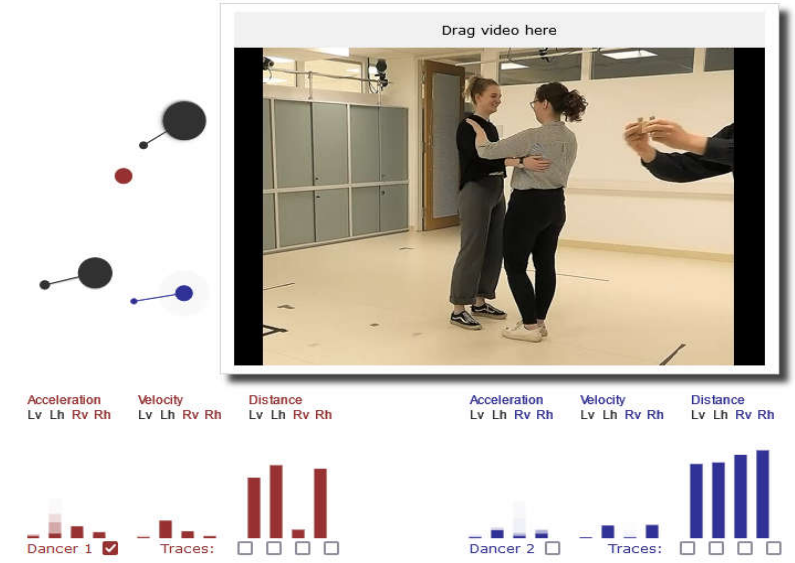
Framework for MoCap data visualisation
MoCap **数据可**视化框架

time accurate synchronization and visualisation of audio/video and MoCap data
Music/video synchronous step visualisation of dancers (e.g. Boogie, Chachacha)
Music/video synchronous analysis of movements combined with audio feature analysis (e.g. Bassoon play)

音频/视频和 MoCap **数据的**时间精确**同步和可**视化

音乐/视频同步舞步可视化(**如** Boogie, Chachacha)

音乐/视频同步分析动作与**音**频特征分析相结合(**例如** **巴松管演奏**)



Systematic Musicology 体系音乐学

5 Scripts and Software to explore

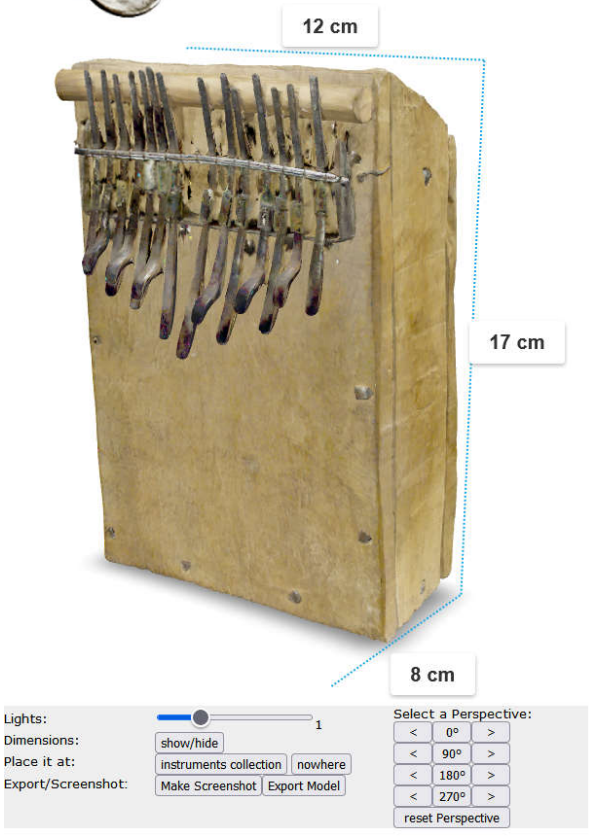
5 脚本和软件探索

Virtualisation of musical Instruments

乐器虚拟化

e.g. Musical instruments made of glass (Trumpet, Flute, Piano, Harmonica, Verrophone) programmed for the Deutsches Museum, Munich

例如, 为慕尼黑德意志博物馆设计的玻璃乐器 (**小号**, 长笛, 钢琴, **玻璃琴**).



3D-scanned musical instruments can be made virtually playable and measured as well as embedded in the virtual instrument collection of the Musicological Institute.

三维扫描乐器**可**进行虚拟演奏**和**测量, **并可嵌入音**乐研**究所的虚**拟乐器收藏中.

Systematic Musicology

5 Scripts and Software to explore

Take Home Message (5)

The Vienna Systematic Musicology provides a number of scripts and software tools that could be interesting for all fields of musicology as well as for digital humanities.

There are tools for statistical analysis, data visualisation for the creation/documentation of interactive environments, for the recording of movements, emotions, (neuro)physiological biodata, eye movements, etc., which can be used for a variety of purposes.

In addition, there is a range of tools for denoising recordings, spectral manipulation of stimuli, spatial acoustic simulations, sound synthesis, etc.

We are looking forward to built up joint projects and collaborations in these or other areas.

体系音乐学

5 脚本和软件探索

带回家的信息 (5)

维也纳体系音乐学提供了许多脚本和软件工具, 这些脚本和工具对音乐学的各个领域以及数字人文都很有意义.

有用于统计分析的工具, 有用于创建/记录互动环境的数据可视化工具, 有用于记录动作, 情绪, (神经) 生理生物数据, 眼球运动等的工具, 这些工具可用于多种目的.

此外, 还有一系列用于对录音进行去噪, 对刺激物进行频谱处理, 空间声学模拟, 声音合成等的工具.

我们期待着在这些领域或其他领域建立联合项目和合作关系.

Systematic Musicology 体系音乐学

1 Timbre Measurement and more / 音色测量及其他

Audio Features of a Chinese Cymbal / 中国钹的音频特征: timbre_features.exe (Flash)
Hardness Map / 硬度映射 (Czedik-Eysenberg, Knauf, Reuter 2017): DGM2017_Czedik_Knauf_Reuter_hard.exe (Flash)
Hardinator / 硬度提取器 (Czedik-Eysenberg, Wiczorek, Reuter 2021): https://muwiserver.synology.me/hardinator/index_m.htm
Darkness Map / 暗度映射 (Czedik-Eysenberg, Knauf, Reuter 2018): DAGA2018_Czedik_Knauf_Reuter_dark.exe (Flash)
Bells Clapper Restauration / 钟声触发恢复 (Reuter, Plitzner, Czedik-Eysenberg, Roos, Siddiq etc. 2022): https://muwiserver.synology.me/glocken/studie1/experts_pleasantness_vorher_nachher.htm
Rooster Annoyance / 公鸡的烦恼 (Reuter, Czedik-Eysenberg, Cui, et al. 2023): https://muwiserver.synology.me/kikeriki/
Electric Car Noises / 电动汽车噪音 (Ambros et al. 2023): https://muwiserver.synology.me/bosch/DAGA2023/size.htm
Motor Bike Sounds / 摩托车声音 (Czedik-Eysenberg, Knauf, Reuter 2015): motorbike3D.exe (Flash)
Audio Logo Features / 音频标志功能 (Czedik-Eysenberg, Anzenbacher, Reuter, Oehler 2014): audiologotimbrespace.exe (Flash)
Bells Breaking Point / 铃声断点 (Reuter, Plitzner, Czedik-Eysenberg, Roos etc. 2023): https://muwiserver.synology.me/hellsbells/bellshell.htm
Bassoon Register Boundaries / 巴松管音域边界 (Reuter 2021): https://muwiserver.synology.me/pitch_sc_register/register_bassoon.htm
HipHop Producers / 嘻哈音乐制作人 (Kudakov, Reuter 2021): https://muwiserver.synology.me/hiphop/mfcc8_spectral_energy_dissonance.htm
Early Jazz Trumpeters / 早期爵士小号手 (Williams, Reuter 2023): https://muwiserver.synology.me/hiphop/mfcc8_spectral_energy_dissonance.htm

2 Sounds you've never heard before / 你从未听过的声音

Sine sweeps for HRTF Measurement / 用于 HRTF 测量的正弦扫频 : GlideSweep-20-20k-0.5s.mp3
General vs. Individual HRTFs / 通用 HRTF 与个体 HRTF : https://muwiserver.synology.me/hrtfs/

3 Living in a Box / 生活在盒子里

Unborn Baby Sounds / 未出生婴儿的声音 (Phelan, Satt 1987): unborn_baby_sounds.wav
Incubator Experience in VR / 虚拟现实中的培养箱体验 (Bertsch, Reuter et al. 2020): https://muwiserver.synology.me/inkubator
Level measurements in dB_A and dB_{SPL} in comparison / 以 dB_A 和 dB_{SPL} 为单位的电平测量值比较 (Reuter et al. 2023): incubator_measurements.png
Interactive dB_A measurements / 交互式 dB_A 测量 **:** https://muwiserver.synology.me/inkubator/messung_5.2.2021/a.htm
Interactive dB_{SPL} measurements / 交互式 dB_{SPL} 测量 **:** https://muwiserver.synology.me/inkubator/messung_5.2.2021/spl.htm
Incubator: sounds inside vs. outside / 培养箱：内部与外部的声音: https://muwiserver.synology.me/inkubator/inside_outside/
Incubator: different types of respiration support in comparision / 培养箱：不同类型的呼吸支持比较 **:** https://muwiserver.synology.me/inkubator/ messung_11.7.2022/respiration.htm
Hearing thresholds of adults, newborns and preterm infants (30 weeks) and different respiration support devices in comparision / 成人、新生儿和早产儿（**30 周**）**的听**阈与不同呼吸辅助设备的比较 (Stummer, Reuter et al. 2023 in preparation): hearing_threshold_adult_newborn_preterm30weeks_ventilations.png

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4 Chilling on the Rocks / 岩石上的寒意

Chills of a test subject when listening several times to "Tuba Mirum“ / 多次聆听 "Tuba Mirum "时，一名受试者起鸡皮疙瘩 (Grewe et al. 2007, S. 305): chills_tuba_mirum.exe (Flash)
Chills of text subjects when listening to Eva Cassidy "What a wonderful world" (sober and alcoholized) / 听伊娃-卡西迪（Eva Cassidy）的 "世界多么美好"（清醒时和酗酒时）时，文字主题令人起鸡皮疙瘩 : chills.exe (Flash)

5 Scripts and Software to explore / 脚本和软件探索

Tools for Data Acquisition and Empirical Research / 数据采集和实证研究工具 : https://arc-lab.univie.ac.at/sysmuwi2tools/
360° Environments / 360° 环境 :
Lecture Hall 1 of the Musicological Department of the University of Vienna / 维也纳大学音乐系 1 号报告厅 : https://muwiserver.synology.me/SoC_MuWi_Hoersaal_1/
Virtual Tromba Experience (Ritual of possession) / 虚拟长号体验（附体仪式）: https://muwiserver.synology.me/tromba1.5/index.htm
Interactive musical instruments collection in VR / 虚拟现实中的交互式乐器收藏 : https://muwiserver.synology.me/instrumentensammlung/
Interactive Cave Acoustics Measurement in VR / VR 中的交互式洞穴声学测量 : https://muwiserver.synology.me/hoehle/

3D MoCap Javascript Framework / 3D MoCap Javascript 框架 : https://muwiserver.synology.me/swing3D/
3D MoCap Javascript Music/video synchronous step visualisation of dancers / 3D MoCap Javascript 音乐/视频同步舞步可视化 :
Boogie / 布吉 : https://muwiserver.synology.me/p5/3Ddances_boogie.htm
Chachacha / 茶卡 : https://muwiserver.synology.me/p5/3Ddances_chachacha.htm
3D MoCap Javascript Music/video synchronous analysis of movements combined with audio feature analysis / 3D MoCap Javascript 结合音频特征分析对动作进行音乐/视频同步分析 : https://muwiserver.synology.me/p5/3Dfagott1.htm

Virtual Glas Musical instruments / 虚拟格拉斯 乐器 :
Trumpet / 小号 : http://muwiserver.synology.me/glastrompete
Flute / 长笛 : http://muwiserver.synology.me/glasfloete
Plate Piano / 板式钢琴 : http://muwiserver.synology.me/glasplattenklavier
Pedal Harmonica / 脚踏口琴 : http://muwiserver.synology.me/glasharmonika_pedal
Verrophone: http://muwiserver.synology.me/verrophon

3D-scanned Lukeme / 三维扫描卢克米 : https://muwiserver.synology.me/p5/3Dlukeme.htm

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Links at infrastructure and devices / 基础设施和设备链接

Semi-anechoic chamber / 半消声室 : https://muwiserver.synology.me/SoC_reflexionsarmer_raum/
Highspeed Video Recordings / 高速视频录制 **:** https://muwiserver.synology.me/videos/highspeed.htm
Acoustic Camera Recordings / 声学摄像机录音 **:** https://muwiserver.synology.me/videos/akustischekamera.htm
Schlieren Video Recordings / Schlieren 视频录像 **:** https://muwiserver.synology.me/videos/schlieren.htm
Bell Measurement of the largest Bell at Vienna Stephansdom / 测量维也纳最大的大钟 : https://www.youtube.com/watch?v=ZZuCsHScjwo
Camera Drone (first flight) / 摄像无人机（首次飞行）: https://muwiserver.synology.me/DJI360Grad/
Maracatu Renascente Ensemble in VR und Ambisonics / VR 和 Ambisonics 中的马拉卡图 **Renascente** 乐团 : https://www.youtube.com/watch?v=VHOVTtMizdQ
Typical Lecture Room Measurement / 典型报告厅测量 **:** https://muwiserver.synology.me/HS27/
The different construction phases of the MediaLab in VR / 虚拟现实媒体实验室的不同建设阶段 : https://muwiserver.synology.me/medienstudio/